PACIFIC SALMON COMMISSION
JOINT CHINOOK TECHNICAL COMMITTEE

DEVELOPMENT OF THE TECHNICAL BASIS FOR A CHINOOK SALMON TOTAL MORTALITY MANAGEMENT REGIME FOR THE PSC AABM FISHERIES

REPORT TCCHINOOK (11)-1

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TABLE OF CONTENTS

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LIST OF ABBREVIATIONS WITH DEFINITIONS

AABM	Aggregate Abundance Based Management
ADFG	Alaska Department of Fish and Game
AEQ	Adult Equivalents (of a number of fish). The hypothetical probability that a fish would survive (i.e., not die naturally) to return to spawn (excludes probability of mortality from fisheries)
AI	Abundance index in an AABM fishery area; on which LC (now) and TM (future) are based (annual)
AI-POST	Postseason Abundance Index
Boat-day	Measure of fishing effort
BOF	Alaska Board of Fisheries
CDFO	Canada Department of Fisheries and Oceans
CNR	Chinook Non-Retention Period (a temporal subdivision of a fishery when Chinook cannot be retained)
CPL	Catch per Landing (used to estimate purse seine encounter rates)
CPUE	Catch per Unit of Effort (or Landing)
CR	Chinook Retention Period (a temporal subdivision of a fishery when Chinook can be retained)
Creel Survey	Dockside sampling of catches in a sport fishery
CTC	Chinook Technical Committee
CWT	Coded wire tag (identifies fish origination: where, when; normally accompanied by an adipose fin clip for ease of sampling)
DIT	Double Indexed Tagged (a fish with a CWT that does not have a fin clip; mimics wild fish in terms of incidental mortality)
drop-off mortality rate	Mortality rate of encountered (hooked) fish that drop-off before being brought to the boat
Encounter(s)	An interaction of a fish with fishing gear; numbers of fish-gear interactions (sublegal- and legal-sized)
EXCEL	A computer spreadsheet program for working with numerical data
FOS	Fishery Operation System (Logbook database of CDFO
IM	Incidental Mortality (in a fishery)
IM Rates	Incidental Mortality rate as a proportions of landed catch
ISBM	Individual Stock Based Management (terminal)
L	Legal-sized Chinook
LC	Landed Catch in AABM fisheries (allowable, annual)
LCE	Landed Catch Equivalencies (used to translate LC to TM)
LIM	Legal sized incidental mortality
LIM CR	Legal sized incidental mortalities (total number) in Chinook retention periods
ITQ	Individual Transferable Quota (fish catch)
LIM CR	Legal sized incidental mortalities (total number) in Chinook retention periods
LIM drop-off	Legal sized Incidental Mortalities (total number) that were drop-off mortalities
LIM:LC ratio	Ratio used in converting LC to TM
LOA	Letter of Agreement (projects)
MR	Maturation Rate
MSF	Mark Selective Fishery (marked fish only retained)
NBC	Northern British Columbia Troll and Queen Charlotte Islands Sport AABM fishery
NSF	Non selective fishery (marked and unmarked fish retained)
PDF	Probability Density Function of Chinook abundance in an area
PNV	Proportion Non-Vulnerable (sublegal sized)
PR	Probability of Recruitment (to ocean age 2)
PSC	Pacific Salmon Commission
PSEE	Purse Seine Encounter Estimator
PV	Proportion Vulnerable (legal sized)
QCI	Queen Charlotte Islands Sport AABM fishery
Release mortality rate	Mortality rate of fish after they are released
S	Survival Rate (natural, in the absence of fishing)
SEAK	Southeast Alaska AABM Fisheries (troll, net, sport)
SFEC	Selective Fishery Evaluation Committee
SIM	Sublegal-sized Incidental Mortality
SIM CR	Sublegal sized Incidental Mortalities (total number) in Chinook Retention periods
SIM Total	Sublegal sized Incidental Mortalities (total number)
SIM:LC ratio	Ratio used in converting LC to TM
SL	Sublegal sized Chinook
SL:L	Ratio of SL:L used to estimate TM
SWHS	Statewide (AK) Mailout Harvest Survey
Table 1 (Annex IV, Chap. 3)	Table relating annual AI to LC (in future, proposed, TM)

LIST OF ABBREVIATIONS WITH DEFINITIONS (CONTINUED)

TCE	Troll Catch Equivalents (gear specific, but also used as a metric to represent LCE for different gear types in a common currency)
TIM	Total Incidental Mortality
TIM:LC ratio	Ratio used in converting LC to TM
TIM_{T+S}	TIM from troll and sport combined
TM	Total Mortality in AABM fisheries (allowable annual)
TMWG	Total Mortality Work Group
WCVI	West Coast Vancouver Island (troll and AABM sport fishery)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

The 2008 Pacific Salmon Treaty directs that "*beginning in 2011, total mortality management shall be implemented*" by revising Table 1 (in Annex IV, Chapter 3) using the 1985-1995 average relationship between incidental mortality (IM) and landed catch (LC) to calculate the total fishing mortality limits at each abundance index (AI) level for each AABM fishery. The Agreement calls for using total mortality (TM) limits, expressed in landed catch equivalents (LCEs), as annual ceilings rather than the LC limits currently in use. The Agreement also directs the Chinook Technical Committee (CTC) to report on how gear allocations and transfers will be handled between sectors; how fisheries will be managed preseason and post-season based on direct and derived observational data; and to evaluate the accuracy of preseason predictions of incidental mortalities, review assumptions, and investigate methods for improving estimates of total mortality in AABM and ISBM fisheries.

This report documents the CTC's extensive efforts to address these directives for AABM fisheries prior to the 2011 season. The report is organized into six primary sections:

- Section I gives the introduction and background for the TM assignments to the CTC.
- Section II develops TM limits for Table 1 from empirically derived 1985-1995 average relationships of IM:LC and LCE scalars based on average adult equivalents (AEQs)
- Section III describes pre- and post-season application of TM regimes in AABM fisheries, and includes comparisons of IM:LC between the 1985-1995 base period and the more recent 1999-2008 period of management under the 1999 Agreement.
- Section IV evaluates the potential effects of changes in mortality allocations among gear sectors and of temporal changes in IM:LC ratios on LC and TM under a TM regime.
- Section V considers caveats and future refinements regarding the implementation of a TM management regime, including impacts of PSC Chinook Model improvements, changes in fishing regulations (e.g., size limits, gear restrictions), development of alternative TM metrics (e.g., the probability of recruitment method), and mark selective fishing.
- Section VI provides a summary and conclusions.

Conversion of Table 1 from LC to TM can be encapsulated in three steps: (1) developing a metric to equate incidental mortalities of sublegal-sized fish to LCEs of legal-sized fish within gear types; (2) developing a metric to represent LCEs for gear types in a common currency, troll catch equivalents (TCEs); and (3) estimation of IM associated with LC. ***An abbreviated version of the TM Table 1 is presented below in Table A. The full TM Table 1 is in Report Table II.2.22.*** The average 1985-1995 IM:LC ratios used for calculating the TM limits are shown in Table B and are summarized in Report Table II.2.23. The average AEQs used as the basis for the LCE scalars are summarized in Report Table II.2.24. The scalars for LCEs within gear sectors are also in Report Table II.2.24. The scalars for translating the gear LCEs to TCEs are summarized in Report Table II.2.25.

Table A. Abbreviated TM Table 1 showing potential TM limits in TCEs at the associated AIs for the three AABM fisheries.

AI	SEAK TM	NBC TM	WCVI TM
0.30	75,490	46,714	49,115
0.495	102,509	77,139	81,007
0.50	103,263	77,857	95,550
0.70	131,036	109,000	133,694
0.90	158,809	140,143	171,965
1.00	172,632	155,715	190,973
1.005	174,140	156,553	219,421
1.20	233,582	186,858	262,029
1.205	263,491	187,696	263,050
1.40	300,689	221,954	305,658
1.50	319,791	239,561	327,473
1.505	344,673	263,038	328,621
1.70	384,887	297,056	371,102
1.90	426,233	332,032	414,731
2.00	446,842	349,520	436,673
2.10	467,578	367,008	458,488

The CTC considered several approaches for developing the scalars to translate LC and IM to LCEs, and ***determined that the AEQ-based approach is the best method currently feasible.*** This method is an improvement over the 1:1 value used in the LC regime, because it accounts for size and maturity differences by stock of both LC and IM in the AABM fisheries. However, because the AEQs are based on probability of survival in the absence of fishing, the AEQ approach may not adequately account for differing stock and age distributions harvested by different gear sectors or size limit differences between gear-type sectors. If TM management is implemented by the Commission, it should be recognized that future revisions to the TM Table 1 may occur as better analytical approaches are developed which lead to refinement and improvement in the transfer scalars.

The CTC found that ***the IM:LC ratios have declined between the 1985-1995 IM base period and the recent period managed under the 1999 Agreement (1999-2008) in all AABM commercial fisheries (Section III).*** The changes are summarized in Table B. These declines are due to management changes that reduced IM. A size limit reduction also contributed to the change with the WCVI troll fishery. As a result, TIM in AABM fisheries is proportionally lower under current LC management than was the case during the IM base period.

Table B. Average IM:LC ratios for the 1985-1995 IM base period and for the 1999-2008 period, and significant differences (P <0.05) between the time periods (values in bold) for the component gear sectors in the three AABM fisheries.

Fishery	TIM:LC		SIM:LC		LIM:LC	
	85-95	99-08	85-95	99-08	85-95	99-08
SEAK Troll	**0.34**	**0.15**	**0.24**	**0.10**	**0.10**	**0.06**
SEAK Net	**1.44**	**0.22**	**1.30**	**0.20**	**0.26**	**0.03**
SEAK Sport	0.26	0.24	0.17	0.13	0.09	0.10
NBC Troll	**0.26**	**0.05**	**0.23**	**0.02**	0.03	0.03
NBC Sport	0.18	0.17	NA	NA	0.18	0.17
WCVI Troll	**0.39**	**0.07**	**0.36**	**0.05**	0.03	0.02
WCVI Sport	0.19	0.19	0.05	0.05	0.14	0.14

Because of the declines in IM:LC ratios, ***transitioning to TM limits for Table 1 based on 1985-1995 IM:LC ratios would potentially result in substantial increases in both TM and LC relative to the LC regime in place under the 2008 Agreement for 2009 and 2010 (Section IV.2).*** Under TM management as defined by the 2008 Agreement, the TM limits would include the IM "savings" realized under current management practices, and thus would have a higher TM limit than the TM currently occurring under the LC Table 1. If an AABM fishery attains these higher TM limits, and current rates of IM:LC are assumed, the realized LC will also be higher than what is currently allowed under the LC Table 1. Comparisons of LC and TM under the current LC and proposed TM regimes are shown for select AIs in Table C; see Report Appendix D for the full range of AIs in Table 1.

Table C. LC and TM expected in the AABM fisheries under the current LC regime and under the proposed TM Regime, and potential percentage increase in LC and TM under the TM regime, for low, average, and high values of AIs which approximate the range of AIs observed for each fishery.

AABM Fishery	AI Level (AI)	LC Regime		TM Regime		% Increase	% Increase
		LC_{lc}	TM_{lc}	LC_{tm}	TM_{tm}	LC	TM
SEAK	Low (0.90)	116,500	127,950	144,350	158,809	23.9	24.1
	Average (1.51)	264,400	291,826	312,095	344,673	18.0	18.1
	High (2.20)	378,600	418,362	441,619	488,187	16.6	16.7
NBC	Low (0.80)	104,000	110,750	115,504	124,572	11.1%	12.5%
	Average (1.30)	170,700	181,779	191,862	204,466	12.4%	12.5%
	High (1.80)	262,600	279,644	297,068	314,544	13.1%	12.5%
WCVI	Low (0.50)	74,900	80,797	84,774	95,550	13.2%	15.4%
	Average (0.75)	112,300	121,141	130,045	143,261	15.8%	15.4%
	High (1.00)	149,700	161,485	175,316	190,973	17.1%	15.4%

The TM limits in the TM Table 1 are based on sector allocations as specified in Appendix B of the 2008 Agreement. However, the management objectives and allocations set by the Parties may differ from the allocations used in Appendix B. The CTC evaluated potential LC under a TM regime at different sector allocations over a range of AIs (Section IV.1). ***The CTC found that the***

change in LC would be relatively small, ranging from 0-3% at average AIs for the AABM fisheries for the range of allocation scenarios examined. Additional scenarios could expand the range of potential change in LC but the effect of adjustments to allocations is much less than the effect of changes in IM:LC ratios from temporal and spatial adjustments to a fishery.

Transitioning to a TM regime would increase the complexity of management and assessment for the respective management agencies and for the CTC (III.1&2). Managers would require gear-specific forecasts of IM to set management regulations to achieve the potential LC. The CTC would continue to report LC and estimates of IM for each gear type within the fishery, but would also need to translate these data into TCEs as the measure of TM.

Under TM management, ***agencies would need to validate encounter estimates from user-reported data (e.g., log books, creel census, mail-out surveys) with direct and independent observations to detect and correct under-reporting biases (Section III.7).*** Costs of such programs are likely to be substantial. Introduction of new monitoring technology could reduce costs but will require consideration on how data are collected and reported. Under LC management, released encounters were reported in the annual reports on catch and escapements by the CTC and accounted for in the calculation of the AI, but they did not affect the LC estimates used to evaluate whether limits under Pacific Salmon Treaty management were exceeded. Under TM management, decreases in reliably estimated incidental mortalities can ultimately result in increased allowable landed catch. This situation creates an incentive to underreport releases and under-scores why fisher-reported data will require validation.

The CTC recommends that empirically-derived relationships of IM:LC ratios from the recent LC management period for estimating IM from LC be used for preseason projections and for post season assessment unless estimates from validated monitoring programs are available post-season. The CTC has developed some preliminary recommendations for predicting IM from LC for each gear sector in each AABM fishery (Section III.4). However, the CTC has not yet developed data standards for assessing whether IM can be reliably predicted, and has not yet assessed whether the predictive relationships meet those standards. Reliability and predictability of estimates of sublegal-sized encounters, as well estimates of incidental mortalities need further review by the CTC. This is due to the greater uncertainty in IM estimates relative to LC and that the IM estimates will become an explicit component of assessment of compliance under the TM regime.

The CTC recommends that these empirically-derived relationships of IM:LC ratios be periodically evaluated through direct observation programs conducted in accordance with standards established by the CTC. In addition, if the management of an AABM fishery is significantly modified (e.g., changes to size limits, implementation of mark selective fisheries (MSF), or time and area regulation), the CTC recommends that: (a) the proposing agency be required to submit methods to be employed to estimate IM for preseason planning for review by the CTC; and (b) agencies be required to conduct direct observation programs in accordance with the standards established by the CTC to estimate IM:LC ratios resulting from the management changes for post season assessment.

For pre- and post-season estimation of TM in LCEs, the CTC will also require estimates of conversion scalars derived from average AEQs from the PSC Chinook Model for computing TCEs. ***The CTC found that average AEQ values from post-season calibrations are adequate to use for calculating LCE scalars and estimating TM for post-season assessments. Average AEQs from***

the preseason Model calibration are also adequate for preseason estimates for the three SEAK sectors and WCVI troll, but not for NBC troll and WCVI sport. The CTC may need to develop and apply methods to reduce the error in preseason estimates of average AEQs in NBC troll and WCVI sport fisheries.

The CTC considered how the PSC Chinook Model could be modified to improve TM management and identified Model improvement issues that apply not only to TM management, but to AABM and ISBM in general (Sections V.1 and 2). The AIs generated by the Model are the basis of annual catch limits in Table 1, whether these limits are defined as LC or TM. The Model has always incorporated estimates of TM in the calculation of cohort sizes and fishery-specific AIs. However, the Model has substantial bias in estimating IM, and currently, does not account for the large temporal decreases in IM under recent management conditions. This could affect the average AEQs for SIMs and LC, and thus the LCE scalars used to construct the TM Table 1. More importantly, inaccurate representation of IM in the model could affect the AIs. ***Thus, changes in the Model to better represent IM could substantially change the time series of AABM AIs in relation to LC that are the basis for Table 1 for LC or TM management. For this reason, the Model improvement work is critical for AABM fisheries management and the construction of Table 1 regardless of whether catch limits are set in terms of LC or TM.***

This report addresses the directives of the 2008 Agreement for transitioning to a TM regime in the AABM fisheries, and provides a technical basis for implementing a TM regime in 2011. The CTC emphasizes that analytical approaches and methods for revising Table 1 from LC to TM, and for implementing and assessing TM management in AABM fisheries, will evolve over time. However, while refinement of LCE scalars used in constructing Table 1 may provide a better "exchange currency" between gear sectors, the change in IM:LC ratios between the 1985-1995 base period and the current period will still result in substantial increases in TM and LC under TM limits relative to the current LC regime. ***The need and priority for the CTC to improve analytical approaches for TM management are dependent on the direction from the Commission regarding transition to a TM regime.***

I INTRODUCTION

In the 1999 Agreement, the Parties to the Pacific Salmon Treaty stipulated an abundance-based, coast-wide Chinook management regime that was divided into two types of fisheries: aggregate abundance-based management regimes (AABM) and individual stock-based management regimes (ISBM). The Parties also agreed to transition AABM fisheries from a management regime based on allowable landed catch (LC) to one based on total mortality (TM). The TM management regime would estimate catch and the associated incidental mortality (IM) in a fishery, and constrain the fisheries based on defined limits to TM rather than LC.

The Chinook Technical Committee (CTC) provides an assessment of the AABM and ISBM fishery regimes and, for AABM fisheries, an estimate of abundance to set annual allowable catch, through its annual exploitation rate analysis and Pacific Salmon Commission (PSC) Chinook Model calibration procedures (e.g., see CTC 2009b). Stock-specific brood year exploitation rates for Chinook indicator stocks are computed using a cohort analysis procedure. This procedure produces a variety of stock-specific statistics, including total exploitation rates, age- and fishery specific exploitation rates, and maturation rates, which are combined with data on catches, escapements, Chinook non-retention (CNR) mortality, sublegal mortality from hook and line gear (shaker mortality), and hatchery production to complete the annual calibration of the PSC Chinook Model.

The PSC Chinook Model is used to determine an annual Abundance Index (AI) for each AABM fishery, which then determines the allowable landed catch (LC) for the fishery based on the AI to LC relationship detailed in Table 1 of Annex IV, Chapter 3. Because the cohort reconstruction and computation of brood year exploitation rates require estimates of TM, TM is a fundamental component of the AABM regime implemented under the 1999 Agreement. However, under a TM regime, the limits on AABM fishing in relation to AI are to be determined in terms of TM instead of LC.

The CTC undertook a number of actions in response to the directive to transition to a TM regime in the 1999 Agreement. The CTC produced a technical report reviewing the estimation and application of incidental fishing mortality in Chinook salmon fisheries under the purview of PSC management (CTC 2004a), and began reporting estimates of incidental mortality of Chinook salmon in PSC fisheries as part of the annual CTC catch and escapement report (CTC 2004b). The CTC also formed a Total Mortality Work Group (TMWG) in 2003 to develop the technical analyses and approaches necessary to implement total mortality regimes. The TMWG made substantial progress on methods for translating the relationship between nominal landed catch and the abundance indexes (AIs) for AABM fisheries into TM units, but was not able to complete the work due to lack of consensus on the interpretation of the TM language in the Agreement.

The 2008 Agreement provided a new directive for transitioning to a TM regime, with more specificity in defining and implementing this management approach. Paragraph 7 of Chapter 3 of the 2008 Agreement states:

The Parties agree:

(a) to adopt total mortality management to constrain fisheries for Chinook salmon based on total fishing mortality, which is the sum of the landed catch and the associated incidental mortalities from fishing, adjusted for landed catch equivalency;

(b) that, to implement total mortality management, estimates of the encounters of Chinook salmon are required, such that estimates:
> *(i) are developed annually from direct observation of fisheries; or*
> *(ii) result from a predictable relationship reviewed by the CTC between encounters and landed catch based on a time series of direct observations of fisheries;*

And further:

(f) that, beginning in 2011, total mortality management shall be implemented as follows:

> *(i) Table 1 of paragraph 10 will be revised, using the average historical relationship between landed catch and incidental mortality observed between 1985 and 1995 across all gears, to calculate the total allowable fishing mortality level for each existing combination of abundance index and allowable landed catch for each AABM fishery,*
>
> *(ii) the annual ceiling for each AABM fishery in a year will be the allowable total fishing mortality expressed in landed catch equivalents;*

In Appendix A, Item 2 to Annex IV, Chapter 3, the Agreement also provides direction to the CTC for the technical work needed to transition to a TM regime:

2) Total Fishing Mortality

with paragraph 7 of this Chapter, the CTC will:

a) Establish standards for the desired level of precision and accuracy of data required to estimate incidental fishing mortality (e.g., encounter rates, estimates of incidental and drop off mortality, stock specific mortalities of marked fish in selective fisheries) to be used for total mortality based management;

b) Complete technical work required to implement total mortality regimes (Paragraph 7) including reporting on the Landed Catch Equivalent (LCE) concept, describe how gear allocations and transfers will be handled between sectors, and how fisheries will be managed pre-season, and post-season based on direct and derived observational data;

c) Describe standardized fishing regimes for all AABM regimes (note: only the description for WCVI requires completion);

d) Evaluate the accuracy of pre-season predictions of incidental mortalities, review assumptions, and investigate methods for improving estimates of total mortality in AABM and ISBM fisheries

This report documents efforts by the CTC to address the directives of the 2008 Agreement relevant to transitioning to TM management in the AABM fisheries prior to the 2011 season. Not included in the report are the CTC review of methods to estimate IM in ISBM fisheries, and the WCVI

Standardized Fishing Regime. The methods in ISBM fisheries will be reviewed by the ISBM workgroup, and the WCVI standardized fishing regime will be completed by the Department of Fisheries and Oceans Canada.

The report is presented in six major sections:

- Section I gives the introduction and background for the TM assignments to the CTC.
- Section II develops the TM Table 1 from empirically derived 1985-1995 average relationships of IM:LC and landed catch equivalent (LCE) scalars based on average adult equivalents (AEQs).
- Section III describes pre- and post-season application of TM regimes in AABM fisheries, and includes comparisons of IM:LC between the 1985-1995 IM base period and the more recent 1999-2008 period of management under the 1999 Agreement.
- Section IV evaluates the potential effects of changes in mortality allocations among gear sectors and of temporal changes in IM:LC ratios on LC and TM under a TM regime.
- Section V considers caveats and future refinements regarding the implementation of a TM management regime, including impacts of PSC Chinook Model improvements, changes in fishing regulations (e.g., size limits, gear restrictions), development of alternative TM metrics (probability of recruitment method), and mark selective fishing.
- Section VI provides a summary of the report and conclusions.

II REVISION OF TABLE 1 TO TOTAL MORTALITY LIMITS

II.1 BASE PERIOD INCIDENTAL MORTALITY ESTIMATES

II.1.A SEAK AABM Incidental Mortality Estimates and 1985-1995 IM Ratios

The following methods were used to estimate the numbers of sublegal-sized and legal-sized Chinook encounters in the SEAK troll, sport, and net Chinook non-retention (CNR) and Chinook retention (CR) fisheries. Incidental mortalities were calculated from these encounters, and the 1985-1995 average ratio of IM to LC was computed for sublegal-sized and legal-sized Chinook salmon. Using LC in the current Table 1 of the 2008 Agreement and these IM ratios, a TM version of Table 1 were constructed.

II.1.A.1 SEAK Troll Fishery

A combination of logbooks and onboard observer programs (direct fishery observations) provided the data for calculation of encounters and corresponding IMs of Chinook salmon in the SEAK summer troll fishery. These direct fishery observation programs were operated in 1985-1988 and 1998-2006 to estimate the number of sublegal-sized and legal-sized Chinook salmon encountered and released during CNR fishing periods. Direct fishery observations were also obtained in 1998-2006 to estimate the number of sublegal-sized Chinook salmon encountered and released during CR fishing periods. Logbook and observer data were stratified temporally by CNR or CR period and spatially by quadrant (Northern Outside, Northern Inside, Southern Outside, Southern Inside: Figure II.1.1). The number of Chinook salmon encountered per boatday was estimated for each stratum as the ratio of the sampled number of encounters to the sampled number of boat-days. This ratio was multiplied by the total boat-days of effort for the stratum to obtain a scaled estimate of encounters for the stratum and fishing period (Bloomquist et al. 1999, Bloomquist and Carlile 2001, Bloomquist and Carlile 2002). The total boat-days of effort for each stratum were estimated from fish tickets with the following tickets being excluded:

1. Tickets with no salmon recorded.
2. Tickets from district 113 where the Chinook catch is less than 20, the coho catch is less than 20, and the chum catch is greater than the sum of the combined catch of Chinook, coho, pink, and sockeye salmon. These were tickets from fisheries targeting chum salmon.
3. Tickets from district 114 where the Chinook catch is less than 20, the coho catch is less than 20, and the pink salmon catch is greater than the sum of the combined catch of Chinook, coho, chum, and sockeye salmon. These were tickets from fisheries targeting pink salmon.

Numbers of Chinook salmon encountered in the summer troll fishery during base period years without direct fishery observations were estimated from one of a series of linear regressions developed from the correlative relationship between summer troll effort and summer encounter estimates from the direct observational years (Appendix A). Sublegal-sized Chinook salmon encountered in the CR period (shakers) in 1985-1995 were estimated using regression model 1 (Appendix A, Table A1). Numbers of legal-sized Chinook salmon encountered in the CNR period in 1989-1995 were estimated using regression model 2 (Appendix A, Table A1). Numbers of sublegal-sized Chinook salmon encountered in the CNR period in 1989-1995 were estimated using regression model 6 (Appendix A, Table A1).

Numbers of sublegal-sized Chinook salmon (shakers) encountered in the winter troll fishery were estimated by multiplying the ratio of the estimated sublegal-sized encounters to LC from the summer CR period by the number of Chinook salmon caught in the winter fishery (see Appendix B, this report). Numbers of sublegal-sized Chinook salmon encountered in the spring troll fishery were estimated by multiplying the same ratio by the number of Chinook salmon caught in the spring fishery (Appendix B, this report).

The numbers of encounters were multiplied by their respective incidental mortality rates (Table II.1.1) to estimate the numbers of incidental mortalities in the SEAK troll fishery (Table II.1.2). Legal-sized drop-off mortalities during CR periods were estimated by multiplying the drop-off mortality rate by the total SEAK troll LC. Legal-sized drop-off mortalities were added to legal-sized CNR mortalities to estimate total legal-sized incidental mortalities (LIM) while sublegal-sized CNR mortalities were added to shakers to obtain an estimate of total sublegal-sized incidental mortalities (SIM, Table II.1.2).

Table II.1.1. Total landed catch (LC), number of legal- and sublegal-sized Chinook salmon encounters, and incidental mortality rates for the SEAK troll fishery, 1985-1995.

		Summer CNR Period		All CR Periods
Year	LC	Legal	Sublegal	Sublegal
1985	215,811	63,275	177,672	131,142
1986	237,703	90,356	97,260	149,419
1987	242,562	158,102	169,828	95,315
1988	231,364	48,635	78,822	61,095
1989	235,716	106,578	132,230	55,760
1990	287,939	88,846	110,230	91,855
1991	264,106	98,385	122,064	44,362
1992	183,759	110,065	136,556	36,855
1993	226,866	86,499	107,317	71,181
1994	186,331	109,582	135,956	44,404
1995	138,117	63,933	79,320	48,346
IM Rates	0.008[1]	0.219[2]	0.263[2]	0.263[2]

[1]drop-off rate from CTC (1997)
[2]drop-off rate + immediate mortality rate from CTC (1997)

Table II.1.2. Estimated Chinook salmon LIMs and SIMs in the SEAK troll fishery, 1985-1995.

Year	LIM Drop-off	LIM CNR	LIM Total	SIM CNR	SIM CR	SIM Total
1985	1,726	13,857	15,584	46,728	34,490	81,218
1986	1,902	19,788	21,690	25,579	39,297	64,877
1987	1,940	34,624	36,565	44,665	25,068	69,733
1988	1,851	10,651	12,502	20,730	16,068	36,798
1989	1,886	23,341	25,226	34,776	14,665	49,441
1990	2,304	19,457	21,761	28,991	24,158	53,148
1991	2,113	21,546	23,659	32,103	11,667	43,770
1992	1,470	24,104	25,574	35,914	9,693	45,607
1993	1,815	18,943	20,758	28,224	18,721	46,945
1994	1,491	23,998	25,489	35,756	11,678	47,435
1995	1,105	14,001	15,106	20,861	12,715	33,576

The number of total LIMs was divided by LC to obtain a ratio for each year from 1985 to 1995 (Table II.1.3). The numbers of total SIMs were also divided by LC to obtain a ratio for the same years (Table II.1.3). The averages of these ratios were then computed as (Table II.1.3):

$$\overline{R}_{LIM_{85\text{-}95}} = \frac{\sum_{y=1985}^{1995} \frac{LIM_y}{LC_y}}{11} \quad \text{(Equation II.1.1)}$$

$$\overline{R}_{SIM_{85\text{-}95}} = \frac{\sum_{y=1985}^{1995} \frac{SIM_y}{LC_y}}{11} \quad \text{(Equation II.1.2)}$$

where $\overline{R}_{LIM_{85\text{-}95}}$ = the average ratio of LIMs to LC from 1985-1995, $\overline{R}_{SIM_{85\text{-}95}}$ = the average ratio of SIMs to LC from 1985-1995, LIM_y = the number of LIMs in year y, SIM_y = the number of SIMs in year y, and LC_y = the LC in year y.

Table II.1.3. Estimated ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for SEAK troll fishery, 1985-1995.

Year	LIM:LC	SIM:LC
1985	0.072	0.376
1986	0.091	0.273
1987	0.151	0.287
1988	0.054	0.159
1989	0.107	0.210
1990	0.076	0.185
1991	0.090	0.166
1992	0.139	0.248
1993	0.091	0.207
1994	0.137	0.255
1995	0.109	0.243
$\overline{R}_{LIM_{85\text{-}95}}$	0.102	-
$\overline{R}_{SIM_{85\text{-}95}}$	-	0.237

II.1.A.2 SEAK Sport Fishery

The number of legal-sized and sublegal-sized Chinook salmon released and corresponding Chinook incidental mortalities in the SEAK sport fishery were estimated from the annual statewide harvest mail-out survey (SWHS) data. The SWHS did not collect both the number of Chinook salmon harvested (fish retained, synonymous with LC) and the number of Chinook salmon caught (fish retained plus fish released) until 1990, thus the only observed estimates of Chinook released prior to 1990 were from the SEAK creel survey program. The creel survey release estimates were not comparable with SWHS estimates so release estimates of legal-sized and sublegal-sized Chinook

for 1985-1989 were calculated using the average ratio of releases to LC from years where SWHS estimates of releases were available. The average ratios of releases to LC for legal- sized and sublegal-sized fish were estimated as:

$$\overline{LR}_{1990-2008} = \frac{\sum_{y=1990}^{2008} \frac{LR_y}{LC_y}}{19} \qquad \text{(Equation II.1.3)}$$

$$\overline{SR}_{1990-2008} = \frac{\sum_{y=1990}^{2008} \frac{SR_y}{LC_y}}{19} \qquad \text{(Equation II.1.4)}$$

where $\overline{LR}_{1990-2008}$ = average legal release to LC ratio from 1990-2008, LR_y = legal releases from SWHS for year y, LC_y = LC from SWHS for year y, $\overline{SR}_{1990-2008}$ = average sublegal release to LC ratio from 1990-2008, and SR_y = sublegal releases from SWHS for year y. These average ratios ($\overline{LR}_{1990-2008} = 0.38$, $\overline{SR}_{1990-2008} = 0.92$) were multiplied by the sport LC from the SWHS for each year for 1985-1989 to obtain estimates of legal and sublegal releases for 1985-1989.

The SWHS Chinook harvest and catch from 1990-1995 was stratified into legal (≥ 28 in) and sublegal (< 28 in) size categories and into fishing sites based on the geographic location of the catch. The SWHS sample design changed three times during the 1990-1995 time period. In 1990 and 1991, a standard survey was mailed to a simple random sample of individuals who purchased Alaska sport fishing licenses during those years (Mills 1991, 1992). Starting in 1992, a standard survey was mailed to a sample of license holders and an additional supplementary survey was mailed to a different sample of license holders (Mills 1993, 1994, Howe et al. 1995, 1996). Starting in 1993, the sample design was changed from a simple random sample design to a stratified random sample design with the following residential strata: Alaska residents, other U.S. residents, Canadian residents, and other foreign residents (Mills 1994). Chinook harvest or catch at each fishing site for each year from 1990-1992 was estimated using the following equation (Mills 1993):

$$\hat{Y}_k = \hat{N}\hat{R}\frac{\sum_{i=1}^{3}\sum_{j=1}^{n_i} y_{ijk}}{\sum_{i=1}^{3} n_i} \qquad \text{(Equation II.1.5)}$$

where $\hat{Y}_k$ = estimated total Chinook harvest or catch within site k, y_{ijk} = harvest or catch at site k by household j from mailing i, n_i = number of households responding to the mailing i, $\hat{N}$ = estimated number of households with at least one fishing license holder, and $\hat{R}$ = SWHS non-response ratio. Chinook harvest or catch at each fishing site for each year from 1993-1995 was estimated using the following equation (Mills 1994):

$$\hat{Y}_{hk} = \hat{N}_h \hat{R}_h \frac{\sum_{i=1}^{3}\sum_{j=1}^{n_{hi}} y_{hijk}}{\sum_{i=1}^{3} n_{hi}} \quad \text{(Equation II.1.6)}$$

where $\hat{Y}_{hk}$ = estimated total Chinook harvest or catch within site k within residential stratum h, y_{hijk} = harvest or catch at site k by household j from mailing i within residential stratum h, n_{hi} = number of households responding to the mailing i within residential stratum h, $\hat{N}_h$ = estimated number of households with at least one fishing license holder within residential stratum h, and $\hat{R}_h$ = SWHS non-response ratio for residential stratum h. The Chinook harvest or catch for SEAK was calculated by summing the estimates of catch and harvest for all fishing sites in SEAK. The numbers of legal-sized and sublegal-sized Chinook released each year from 1990-1995 were calculated by subtracting the size-specific estimate of the number of Chinook harvested from the size-specific estimate of the number of Chinook caught. The numbers of releases were multiplied by their respective incidental mortality rates (Table II.1.4) to estimate the numbers of LIMs and SIMs in the SEAK sport fishery (Table II.1.5). Legal-sized drop-off mortalities were estimated by multiplying the drop-off mortality rate by the total SEAK sport harvest. Legal-sized drop-off mortalities were added to legal-sized release mortalities to estimate total LIMs (Table II.1.5). The average ratios of LIMs to LC and SIMs to LC for the SEAK sport fishery from 1985-1995 were estimated using equations II.1.1 and II.1.2 (Table II.1.6).

Table II.1.4. Total LC, number of legal-sized and sublegal-sized Chinook salmon releases, and incidental mortality rates for the SEAK sport fishery, 1985-1995.

Year	LC	Legal-sized	Sublegal-sized
1985	24,858	9,548	22,869
1986	22,551	8,662	20,747
1987	24,324	9,343	22,378
1988	26,160	10,048	24,067
1989	31,071	11,934	28,585
1990	51,218	21,789	118,683
1991	60,492	7,765	43,916
1992	42,892	25,799	53,273
1993	49,246	18,209	41,733
1994	42,365	10,180	44,836
1995	49,667	13,170	44,994
IM Rates	0.036[1]	0.159[2]	0.159[2]

[1] Drop-off rate from CTC (1997)
[2] Drop-off rate + immediate mortality rate from CTC (1997)

Table II.1.5. Estimated Chinook salmon LIMs and SIMs in the SEAK sport fishery, 1985-1995.

Year	LIM Drop-off	LIM CR	LIM Total	SIM Total
1985	895	1,518	2,413	3,636
1986	812	1,377	2,189	3,299
1987	876	1,486	2,361	3,558
1988	942	1,598	2,539	3,827
1989	1,119	1,898	3,016	4,545
1990	1,844	3,464	5,308	18,871
1991	2,178	1,235	3,412	6,983
1992	1,544	4,102	5,646	8,470
1993	1,773	2,895	4,668	6,636
1994	1,525	1,619	3,144	7,129
1995	1,788	2,094	3,882	7,154

Table II.1.6. Estimated ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for SEAK sport fishery, 1985-1995.

Year	LIM:LC	SIM:LC
1985	0.097	0.146
1986	0.097	0.146
1987	0.097	0.146
1988	0.097	0.146
1989	0.097	0.146
1990	0.104	0.368
1991	0.056	0.115
1992	0.132	0.197
1993	0.095	0.135
1994	0.074	0.168
1995	0.078	0.144
$\overline{R}_{LIM_{85-95}}$	0.093	-
$\overline{R}_{SIM_{85-95}}$	-	0.169

II.1.A.3 SEAK Net Fishery

Four commercial net gear types (setnet, drift gillnet, trap net and purse seine) operate in SEAK and most of the fishing effort is directed at salmon species other than Chinook salmon. These fisheries are more terminal than the troll and sport fisheries. The set gillnet fishery operates in the Yakutat area and is conducted near or in rivers in that area, and few Chinook salmon are taken. The drift gillnet fishery operates in marine waters in 5 districts from Lynn Canal (District 115) in the north to Tree Point (District 101) in the south (Figure II.1.1). With the exception of District 101, these fisheries are primarily directed at terminal runs of returning sockeye, chum and coho salmon. The trap net fishery is a small fishery restricted to the waters of the Metlakatla Indian Reservation, in district 101. The purse seine fishery occurs throughout SEAK, and is directed primarily at pink and chum salmon.

Annual LC and encounters for the net fisheries were compiled by combining set and drift gillnet catches and trap net and purse seine catches (Table II.1.7). All fish caught in the gillnet fishery can be retained and sold so CNR or sublegal-sized designations did not apply. Thus, the computation of IM in the gillnet fishery was limited to estimating LIM by applying the appropriate drop off mortality rate from CTC (1997) to the LC. For the seine fishery, encounter estimates were needed to estimate SIM during CR periods, and to estimate LIM and SIM during CNR periods.

CNR periods were initiated in the purse seine fishery in 1985 in response to the rebuilding program for Chinook salmon that was implemented in the original Pacific Salmon Treaty. To estimate the CNR encounters and mortalities associated with the newly created CNR periods, the Alaska Department of Fish and Game (ADF&G) conducted CNR encounter studies of the purse seine fishery from 1985 to 1988. From the late 1980s through the early 2000s no subsequent CNR studies were conducted and it became apparent that more current information was needed on the magnitude of CNR impacts. Therefore, in 2004 and 2005 a logbook program was implemented to estimate the number of CNR encounters in the purse seine fishery. The studies from these 6 years provided the base data that were used to develop a purse seine encounter estimator (PSEE). The PSEE uses the magnitude of the LC, and the length and timing of the CR and CNR periods to predict the legal-sized and sublegal-sized CNR encounters in years where no studies were available.

The 1985 and 1986 observer studies estimated CNR encounters using three different methods: (1) a pink to Chinook ratio method; (2) a Chinook per set method; and (3) an average catch per landing method (Van Alen and Seibel 1986, 1987). The Chinook per set method was chosen as the most reliable method of predicting the Chinook encounters. In 1986, a 28 in minimum size limit for legal-sized Chinook was implemented in the SEAK purse seine fishery. Chinook from 21 to 28 in could not be sold but Chinook less than 21 in could be sold since they are difficult to distinguish from pink salmon that are the primary target of the fishery. Because no size limits were in place in 1985, the 1985 encounter estimates were stratified by weight (very small: < 3 lb, small: >3 lb and < 5 lb, medium: >5 lb and <1 lb, and large: >11 lb). An analysis of available CWT data from the purse seine fishery indicated that the majority of the medium and large fish are over 28 in, so these categories were combined to estimate the legal-sized encounters in 1985. Because there was no size limit in 1985, the reported Chinook catch contains legal-sized and sublegal-sized Chinook. An analysis of the Chinook encounter estimates from the CR periods in years after the slot limit was instituted indicated that approximately 75% of the Chinook catch in the seine fishery was 28 in or greater. Therefore, the estimate of LC 28 in or greater in 1985 was estimated by multiplying the total Chinook LC by 0.75.

In 1987 two methods, catch per unit effort (CPUE) from dockside interviews and fish tickets, were used to estimate Chinook encounters in the seine fishery for both the CR and CNR periods (Rowse and Marshall 1989). The dockside interview method was the most reliable for estimating the sublegal-sized encounters and the fish ticket method was the most reliable for estimating the legal-sized encounters. In 1988 the Chinook encounter estimates for both the CR and CNR periods were derived solely from the dockside interview method (Rowse 1990). The 1988 encounter estimates used in the development of the PSEE differ slightly from the numbers reported by Rowse (1990) due to the discovery of a spreadsheet error that affected the estimates in one of the area strata in the original document.

In 2004 and 2005 the Chinook encounter estimates were derived using logbook CPUE expanded to the total fishery. In 2004, encounter estimates were made for both the CR and CNR periods.

Unfortunately, there were no CNR periods in 2005 and therefore, the only Chinook encounter estimates for 2005 are for the CR period.

A catch per landing (CPL) approach was used to estimate the seine encounter rates. The average weekly Chinook CPL for the years 1985-2009 was used to construct an empirical probability density function (PDF) of the Chinook abundance in the SEAK seine fishery during the summer fishing period (statistical weeks 25-40). However, the seine fishery has periods of CNR that vary from year to year, with the result that there are statistical weeks where there is no LC with which to calculate the CPL. This complicates the estimation of the average CPL for each statistical week since a simple arithmetic mean would contain missing data for those years in which there was CNR in the statistical week of interest. Construction of an empirical PDF based on weekly CPL averages from different sets of years would be nonsensical since the average CPL in each statistical week would be influenced by the inter-annual variation in the total yearly abundance. The object of interest in this context is the intra-annual variation in the CPL across the statistical weeks for use in constructing the empirical PDF and the effect of the inter-annual variation in the total year abundance is something that needs to be removed. To remove the effect of the total yearly abundance, the ratio of the CPL value in each statistical week to the CPL value from the prior statistical week was computed for each statistical week in each year (*Δcpl*). The assumption that was made was that even though the total yearly abundances varied in magnitude, the relative magnitude of the CPL value in each statistical week to the CPL value from the prior statistical week within each year was consistent across years. The weekly *Δcpl* values were then averaged across all years of available data in order to compute the average *Δcpl*. Since there was no CPL data prior to statistical week 25 each year, the average *Δcpl* for statistical week 25 was fixed at 1. A relative CPL for each statistical week was then constructed by multiplying the average *Δcpl*s from statistical week 25 up through the statistical week of interest. The relative CPL in each statistical week was then divided by the sum of the relative CPLs across all statistical weeks to compute the values of the empirical PDF for each statistical week.

$$\overline{\Delta cpl}_w = \frac{\displaystyle\sum_{y \in VT_w} \frac{\left(\dfrac{C_{y,w}}{l_{y,w}}\right)}{\left(\dfrac{C_{y,w-1}}{l_{y,w-1}}\right)}}{n_{VT_w}} = \frac{\displaystyle\sum_{y \in VT_w} \left(\frac{C_{y,w}}{l_{y,w}}\right) * \left(\frac{l_{y,w-1}}{C_{y,w-1}}\right)}{n_{VT_w}} \qquad \text{(Equation II.1.7)}$$

where $\overline{\Delta cpl}_w$ = average change in the weekly Chinook catch-per-landing from the prior week for w > 25 and $\overline{\Delta cpl}_w = 1$ for w > 25 and $\overline{\Delta cpl}_w = 1$ for $w = 25$, $C_{y,w}$ = Catch in year y and statistical week w, $l_{y,w}$ = landings in year y and week w, n_{VYw} = number of valid years for week w, and VY_w = valid years for week w. Valid years are years for which the CPL in statistical weeks *w* and *w*-1 and the change in CPL from statistical week *w*-1 to statistical week *w* can all be calculated (i.e. $l_{y,w} > 0$, $l_{y,w-1} > 0$ and $C_{y,w-1} > 0$.)

The empirical estimate of the density of the Chinook CPL is

$$d_{w^*} = \frac{\prod_{w=25}^{w^*} \overline{\Delta cpl_w}}{\sum_{w=25}^{40}\left(\prod_{w=25}^{40} \overline{\Delta cpl_w}\right)} \qquad \text{(Equation II.1.8)}$$

in statistical week w*, which is used as a surrogate for the density of the Chinook abundance in statistical week w*.

The next step was to use the magnitude of LC and the legal-sized and sublegal-sized CNR encounter estimates from years in which observational studies were in place to establish average relationships between the yearly LC and the magnitudes of legal-sized and sublegal-sized CNR encounters. The data from the years with observational studies are summarized in Appendix C. These relationships were constructed in a manner designed to negate the effects of the length and timing of the yearly CNR periods on the LC as well as the number of legal-sized and sublegal-sized CNR encounters. In addition, the relationships were designed to be independent of the amount of effort in both the CR and CNR periods. First, the weekly catches between years were standardized to account for the fact that the LC was a function of the amount of effort expended. To accomplish this task the LC in each statistical week was scaled to a standardized LC per 1,000 landings. This involved multiplying the weekly LC by 1,000 and dividing by the number of actual landings in the statistical week. Second, the total yearly standardized Chinook LC was estimated if there had been no CNR periods. For each year, this "scaled" LC was calculated by dividing the sum of the standardized weekly catches by the sum of the weekly PDF values corresponding to the weeks the fishery was open to the retention of Chinook salmon. The equation for the scaled catch was

$$SC_y = \frac{\sum_{w\in R_y}\left[C_{y,w} * \left(\frac{1000}{l_{y,w}}\right)\right]}{\sum_{w\in R_y} d_w} = \frac{1000 * \sum_{w\in R_y}\left(\frac{C_{y,w}}{l_{y,w}}\right)}{\sum_{w\in R_y} d_w} \qquad \text{(Equation II.1.9)}$$

where $C_{y,w}$ = catch in year y and statistical week w, $l_{y,w}$ = landings in year y and week w, d_w = empirical PDF value in statistical week w and R_y = Chinook retention period in year y. This resulted in a scaled yearly LC estimate that represented what would have been caught had the fishery been open for CR every week, and if there had been 1,000 landings every week.

Standardized legal-sized and sublegal-sized CNR encounter estimates were calculated by multiplying the CNR encounter estimates by the number of weeks of CNR and 1,000 landings and then dividing by the sum of the landings from weeks with CNR. "Scaled" CNR encounter estimates were then calculated by dividing the standardized CNR encounter estimates by the sum of the weekly PDF values corresponding to the weeks the fishery was under CNR management.

Scaled legal-sized CNR encounters were calculated as

$$SL_y = \frac{L_{N_y} * \left(\frac{\sum_{w\in N_y} 1000}{\sum_{w\in N_y} l_{y,w}}\right)}{\sum_{w\in N_y} d_w} = \frac{1000 * W_{N_y} * L_{N_y}}{\sum_{w\in N_y} l_{y,w} * \sum_{w\in N_y} d_w} \qquad \text{(Equation II.1.10)}$$

where N_y = CNR period in year y, W_{N_y} = Total number of statistical weeks in the CNR period in year y and L_{N_y} = Legal-sized encounters during the CNR period in year y.

Scaled sublegal-sized CNR encounters were calculated as

$$SS_y = \frac{S_{N_y} * \left(\frac{\sum_{w \in N_y} 1000}{\sum_{w \in N_y} l_{y,w}} \right)}{\sum_{w \in N_y} d_w} = \frac{1000 * W_{N_y} * S_{N_y}}{\sum_{w \in N_y} l_{y,w} * \sum_{w \in N_y} d_w} \qquad \text{(Equation II.1.11)}$$

where S_{N_y} = Sublegal-sized encounters during the CNR period in year y. This resulted in yearly estimates of the scaled legal-sized and sublegal-sized CNR encounters that represented what would have been encountered had the fishery been under CNR every week and if there had been a standardized 1,000 landings every week.

Lastly the ratios of scaled legal-sized CNR encounters to scaled Chinook catch (LCR) and scaled sublegal-sized CNR encounters to scaled Chinook catch (SCR) were averaged over the years with observational data. For legal-sized CNR encounters,

$$\overline{LCR_O} = \frac{\sum_{y \in O} \left(SL_y / C_{y,\cdot} \right)}{n_O} \qquad \text{(Equation II.1.12)}$$

where $C_{y,\cdot}$ = total catch in year y and n_O = number of years with observational data.

For sublegal-sized CNR encounters,

$$\overline{SCR_O} = \frac{\sum_{y \in O} \left(SS_y / C_{y,\cdot} \right)}{n_O} \qquad \text{(Equation II.1.13)}$$

These average scaled ratios provided a means to estimate the number of legal-sized and sublegal-sized CNR encounters in years with CNR but without observational studies. The Chinook catches in these years were converted to scaled Chinook catch using the procedures outlined above. The scaled Chinook catches were then multiplied by the average LCR and SCR ratios to produce estimates of the scaled legal-sized and sublegal-sized CNR encounters. The scaled legal-sized and sublegal-sized CNR encounters were then converted to the final yearly CNR encounter estimates by multiplying the scaled encounters by the sum of the PDF values during the statistical weeks with CNR, multiplying the result by the sum of the landings during the statistical weeks with CNR and then finally dividing by the number of statistical weeks of CNR multiplied by 1,000. Legal-sized encounters during the CNR period in year *y* were estimated by

$$\hat{L}_{N_y} = \overline{LCR_O} * \frac{\sum_{w \in N_y} l_{y,w} * \sum_{w \in N_y} d_w}{1000 * W_{N_y}} \qquad \text{(Equation II.1.14)}$$

Sublegal-sized encounters during the CNR period in year *y* were estimated by

$$\hat{S}_{N_y} = \overline{SCR_O} * \frac{\sum_{w \in N_y} l_{y,w} * \sum_{w \in N_y} d_w}{1000 * W_{N_y}} \qquad \text{(Equation II.1.15)}$$

The annual estimates from the CPL approach of encounters of legal-sized and sublegal-sized fish during seine CNR periods, and of sublegal-sized encounters during seine CR periods are compiled in Table II.1.7.

Table II.1.7. Total LC, number of legal-sized and sublegal-sized Chinook salmon encounters, and associated incidental mortality rates for the SEAK gillnet and seine fisheries, 1985-1995.

			Seine CNR Period		Seine CR Period
Year	Gillnet LC[3]	Seine LC[4]	Legal-sized	Sublegal-sized	Sublegal-sized
1985	11,911	21,959	12,426	44,679	10,381
1986	9,967	12,132	13,773	26,850	7,875
1987	11,029	4,503	1,920	9,018	5,163
1988	10,552	11,236	12,946	10,834	8,717
1989	10,746	13,499	17,886	47,104	7,687
1990	15,880	11,832	8,840	23,280	6,127
1991	21,001	13,863	8,062	21,232	8,449
1992	13,765	18,375	50,760	133,679	11,481
1993	19,591	8,400	6,090	16,038	4,378
1994	20,815	14,839	20,745	54,634	8,018
1995	22,838	25,117	14,896	39,229	1,388
IM Rates	0.02[1]		0.51[2]	0.735[2]	0.858[2]

[1] Gillnet drop-off rate from CTC (1997).
[2] Drop-off rate + immediate mortality rate from CTC (1997).
[3] Includes set net catch.
[4] Includes trap catch.

The encounter estimates and mortality rates in Table II.1.7 were then used to generate estimates of LIM and SIM for the net fishery (Table II.1.8). Cumulative annual estimates of LIM and SIM were divided by LC to calculate the IM:LC ratios for 1985-1995 using equations II.1.1 and II.1.2 (Table II.1.9).

Table II.1.8. Estimated Chinook salmon LIMs and SIMs in the SEAK net fishery,1985-1995.

Year	LIM Drop-off	LIM CNR	LIM Total	SIM CNR	SIM CR	SIM Total
1985	238	6,337	6,575	32,839	8,907	41,746
1986	199	7,024	7,224	19,735	6,756	26,491
1987	221	979	1,200	6,628	4,430	11,058
1988	211	6,602	6,813	7,963	7,479	15,442
1989	215	9,112	9,337	34,621	6,595	41,217
1990	318	4,508	4,826	17,111	5,257	22,368
1991	420	4,112	4,532	15,605	7,249	22,854
1992	275	25,887	26,163	98,254	9,851	108,105
1993	392	3,106	3,498	11,788	3,757	15,545
1994	416	10,580	10,996	40,156	6,880	47,036
1995	457	7,597	8,054	28,833	1,191	30,024

Table II.1.9. Estimated ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for SEAK net fishery, 1985-1995.

Year	LIM:LC	SIM:LC
1985	0.194	1.233
1986	0.327	1.199
1987	0.077	0.712
1988	0.313	0.709
1989	0.385	1.700
1990	0.174	0.807
1991	0.130	0.656
1992	0.814	3.364
1993	0.125	0.555
1994	0.308	1.319
1995	0.168	0.626
$\overline{R}_{LIM_{85-95}}$	0.274	-
$\overline{R}_{SIM_{85-95}}$	-	1.171

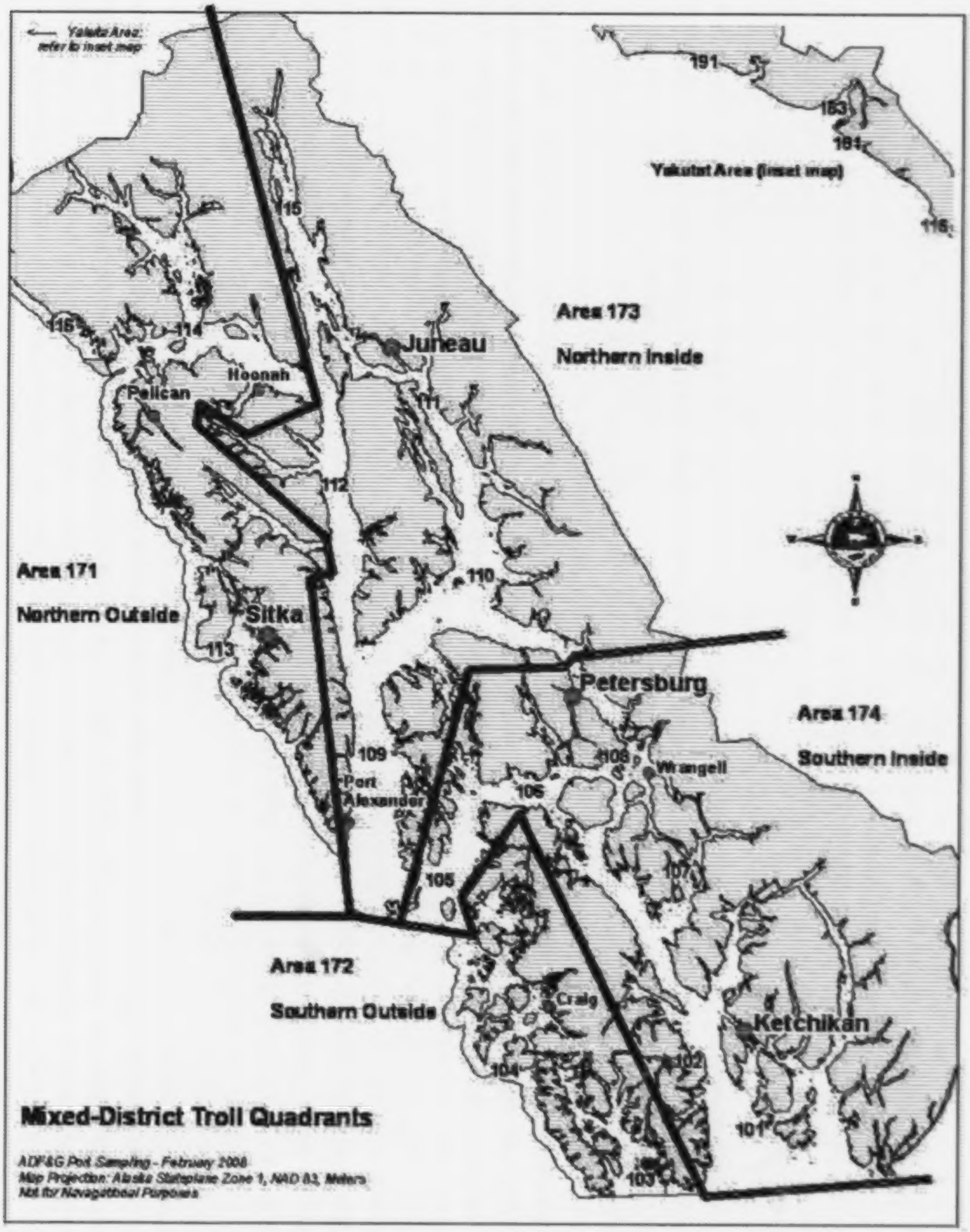

Figure II.1.1. Map of Southeast Alaska showing the boundaries of the four management quadrants, the statistical districts within them and locations of selected communities.

II.1.B NBC AABM Incidental Mortality Estimates and 1985-1995 IM Ratios

The following sections describe the approaches used to estimate encounters of sublegal- and legal-sized Chinook in CNR and CR fisheries in the NBC troll and sport fisheries. Incidental mortalities were calculated from these encounters, and the 1985-1995 average ratio of IM to LC was computed for sublegal-sized and legal-sized Chinook. Using LC in the current Table 1 of the 2008 Agreement and these IM ratios, a TM version of Table 1 was constructed for NBC.

II.1.B.1 NBC Troll Fishery

The NBC troll fishery takes place in Pacific Fishery Management Areas 1–5, 101-105 and 142 (Figure II.1.2). These are referred to informally as statistical areas 1–5 with areas 1 and 3 adjoining the international boundary with Alaska. From 1985-1995, catch in this fishery occurred during May through October, with the majority occurring from July through September (Table II.1.10). Spatially, statistical area 1 accounted for most of the catch (58%; see Figure II.1.3) followed by area 2W (27%). Consequently, estimates of incidental mortalities for the base period are most influenced by encounter rates from the summer period in area 1.

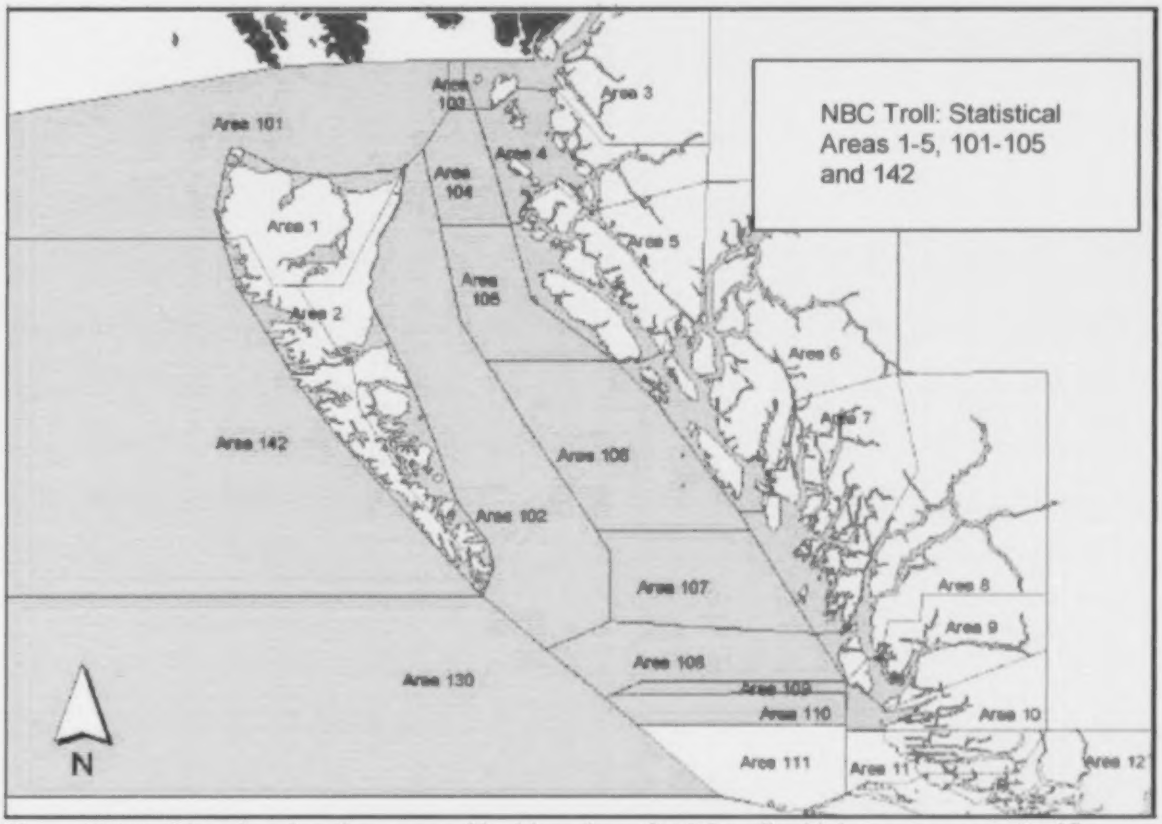

Figure II.1.2. Map showing the geographical location of NBC troll which encompasses Pacific Fishery Management Areas 1-5, 101-105, and 142.

No direct observational data of Chinook encounters are available from the base period years. The closest period from which data are available is 1981-1983 when a study to investigate sublegal encounter rates was implemented in NBC troll and WCVI troll (Healey et al. 1985). This study involved multiple trollers who volunteered to maintain logbooks and fish as they would under normal circumstances. The study participants recorded the number of Chinook retained and the number released. In addition, they took length measurements from a sample of their daily retained catch. Observers were placed on board participating vessels in the first year, but due to the high quality of data collected that year and the enthusiasm of the participants in the program, the use of observers was discontinued for the last two years. Data from all three years were considered of high quality (Healey et al. 1985). All data were collected during CR fisheries as there were no CNR fisheries during the study period.

Table II.1.10. Mean percent distribution of NBC troll catch by statistical area and month for the 1985-1995 troll accounting years. The bottom row shows the simple average across statistical areas.

Stat Area	Month									
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0%	0.0%	0.3%	0.5%	57.5%	31.5%	9.4%	0.8%	0.0%	0.0%
2E	0.0%	0.0%	0.3%	0.1%	59.0%	24.0%	15.3%	1.3%	0.0%	0.0%
2W	0.0%	0.0%	0.2%	0.1%	41.6%	41.3%	13.9%	2.9%	0.0%	0.0%
3	0.0%	0.0%	1.5%	5.4%	68.5%	16.9%	6.7%	1.0%	0.0%	0.0%
4	0.0%	0.0%	0.9%	1.5%	72.1%	19.1%	6.2%	0.2%	0.0%	0.0%
5	0.0%	0.0%	0.1%	0.2%	70.4%	24.9%	4.4%	0.0%	0.0%	0.0%
All	0.0%	0.0%	0.3%	0.5%	54.3%	32.7%	10.7%	1.4%	0.0%	0.0%

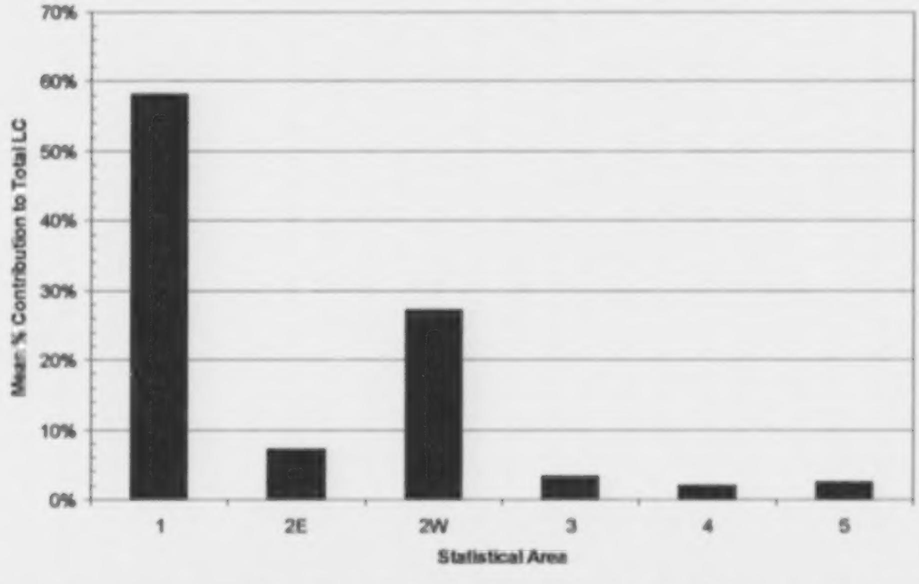

Figure II.1.3. Mean percentage distribution of the NBC troll catch by statistical area, 1985-1995.

Data from the 1981-1983 Chinook encounter study were used to develop encounter rates of sublegal-sized Chinook for the 1985-1995 base period. Visual inspection of the data indicated possible temporal and spatial patterns in encounters with sublegal-sized Chinook relative to legal-sized Chinook. The encounter data were, therefore, stratified by statistical area and month for the analysis. In order to increase overall sample sizes, and to reduce variability in encounter rate estimates, catches and releases were summed across the three years for each area x month stratum and a single encounter rate value was calculated (Table II.1.11). A minimum size limit of 62 cm fork length, (FL) was in effect during the study and during 1985 and 1986, so the encounter rates in 1985 and 1986 were assumed to be the same as those from the study. In 1987, the size limit for the fishery was increased from 62 cm to 67 cm FL and remained unchanged for the rest of the base period. Given that the study data were collected at the lower size limit, the sublegal encounter rates had to be recomputed as if they had occurred under the higher size limit. This was accomplished by multiplying the retained catch by the proportion of the length-sampled catch that was $\geq$62 cm but <67 cm to obtain an estimate of sublegal-sized fish that were not sublegal under the 62 cm size limit. These new sublegal fish are then subtracted from the observed catch and added to the sublegal category. These modified data were then used to obtain sublegal encounter rates for years under the 67 cm size limit (Table II.1.12).

Table II.1.11. Ratio of sublegal-sized Chinook salmon encounters to legal-sized encounters by month and statistical area in NBC troll under a 62 cm FL size limit. These sublegal encounter rates apply to base period years 1985 and 1986. Values in bold font are the adjusted cell means from an ANOVA, the results of which were used to complete strata with no actual data.

Statistical	Month							
Area	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1	0.186	0.145	0.153	0.326	0.123	0.109	**0.203**	**0.203**
2E	0.357	0.674	0.541	1.176	1.171	**0.977**	**0.977**	**0.977**
2W	**0.142**	0.000	**0.106**	0.405	0.139	0.088	**0.203**	**0.203**
3	**0.680**	**0.811**	**0.510**	1.177	**0.696**	**0.977**	**0.977**	**0.977**
4	**0.680**	1.536	0.828	0.272	**0.696**	**0.977**	**0.977**	**0.977**
5	**0.680**	**0.811**	**0.510**	**0.966**	**0.696**	**0.977**	**0.977**	**0.977**

Table II.1.12. Ratio of sublegal-sized encounters to legal-sized encounters by month and statistical area in NBC troll under a 67 cm FL size limit. These sublegal encounter rates apply to base period years 1987-1995. Values in bold font are the adjusted cell means from ANOVA which was used to complete strata with insufficient or no observed data.

	Month							
Statistical Area	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1	0.241	0.222	0.306	0.428	0.245	0.208	**0.317**	**0.317**
2E	0.420	1.463	1.363	3.149	**1.370**	**1.307**	**1.307**	**1.307**
2W	**0.234**	0.433	**0.231**	1.083	0.224	0.187	**0.317**	**0.317**
3	**0.965**	**1.190**	**0.953**	0.849	**1.160**	**1.307**	**1.307**	**1.307**
4	**0.965**	0.651	1.208	3.680	**1.160**	**1.307**	**1.307**	**1.307**
5	**0.965**	**1.190**	**0.953**	**1.835**	**1.160**	**1.307**	**1.307**	**1.307**

An encounter rate was not calculated for a stratum if retained catch, under either size limit, was less than 10 fish across the three years. These 'empty' strata were filled with encounter rates estimated using an un-weighted means ANOVA. The model was fitted using two independent categorical

variables, 'statistical area group' and 'month group' (see Table II.1.13), to predict mean natural log-transformed sublegal encounter rates. Mean encounter rate estimates for empty strata were also required for the WCVI troll fishery and thus, the statistical area groupings included WCVI areas as well as actual data for the WCVI areas. Area and month groupings were formed through exploratory analysis of the encounter rate data. Two separate analyses were performed, one for encounter rate data computed under the 62 cm size limit and one for data computed under the 67 cm size limit. Each analysis resulted in a statistically significant model (62 cm size limit: $F_{9,47}$ = 11.309, $p<0.001$, R^2=0.684; 67 cm size limit: $F_{9,48}$ = 14.345, $p<0.001$, R^2=0.729). The adjusted cell means generated from each model for the missing strata were transformed back to base 10 values for further use in calculating sublegal-sized encounters from observed LC in each base period year.

Table II.1.13. Categorical groupings of statistical areas and months used to approximate sublegal encounter rates for unfilled time-area strata through ANOVA. Groupings were selected according to expected similarity among sublegal encounter rates.

Statistical Area Group	Statistical Area(s)	Month Group	Month(s)
1 (NBC)	1, 2W	1	Apr
2 (NBC)	2E, 3, 4, 5	2	May
3 (WCVI)	21	3	Jun
4 (WCVI)	23, 24	4	Jul
5 (WCVI)	25, 26, 27	5	Aug
		6	Sep, Oct, Nov

Other approaches could have been used to generate acceptable data for the missing strata (e.g., use of values from adjacent of closest filled strata). Catches in the unfilled strata are small, however, and the choice of approach has little impact on the total annual estimates of sublegal encounters.

From the completed matrices of encounter rates, estimates of total sublegal encounters in the CR fishery (i.e., releases) could be calculated for each year in the base period. This was done by multiplying the LC observed in each area x month stratum by the size limit-appropriate encounter rate from the same stratum. An annual total of sublegal encounters in the CR fishery was obtained by summing these estimates across all area x month strata (see the right-most column in Table II.1.15). Estimates of SIMs for CR fisheries were calculated by multiplying the sublegal-sized encounters by the CTC-accepted release mortality rate and drop-off mortality rate for sublegal-size Chinook. LIMs were obtained by multiplying the observed annual LC by the CTC-accepted legal-sized drop-off rate (Table II.1.16).

CNR fisheries did occur in NBC troll during 9 of 11 years in the base period. No actual data are available from CNR periods to provide estimates of encounters of legal-sized or sublegal-sized fish from the base period. Data generated from PSC Chinook Model calibration 0907 were employed in the absence of observed data as a means of estimating IM associated with CNR periods.

The Chinook Model generated estimates of model LC, CNR LIM and CNR SIM (Table II.1.14) using either the season length ratio or effort ratio methods previously defined in CTC (2004a). Estimates of 'actual' CNR LIM were computed by multiplying observed LC by the ratio of model CNR LIMs to model LC. Actual SIMs were obtained by multiplying actual LIMs by the ratio of model CNR SIMs to model CNR LIMs (Table II.1.14 and Table II.1.16). These IM estimates could

then be converted into encounters by dividing by the appropriate size-specific release mortality rates and drop-off rates for purposes of completing Table II.1.15.

Table II.1.14. Estimates of CNR nominal incidental mortalities, LIM and SIM, and LC for NBC troll fisheries, 1985-1995, from PSC Chinook Model calibration 0907.

Year	Model LC	LIM	SIM	LIM:LC	SIM:LIM
1985	174,767	0	0	0	0
1986	162,747	0	0	0	0
1987	175,289	1,179	7,572	0.007	6.421
1988	150,507	2,047	11,469	0.014	5.603
1989	205,144	192	1,161	0.001	6.060
1990	152,232	2,354	13,078	0.015	5.555
1991	191,644	994	6,042	0.005	6.081
1992	140,596	2,345	14,256	0.017	6.080
1993	159,799	1,551	8,589	0.010	5.539
1994	162,483	833	4,184	0.005	5.025
1995	56,168	2,518	16,079	0.045	6.386

Table II.1.15. Observed LC, estimated number of legal- and sublegal-sized Chinook salmon encounters and IM rates for the NBC troll fishery, 1985-1995.

		CNR Periods		CR Periods
Year	LC	Legal	Sublegal	Sublegal
1985	165,845	0	0	45,607
1986	175,715	0	0	72,196
1987	177,457	5,658	30,062	119,300
1988	152,369	9,821	45,532	104,280
1989	207,679	919	4,609	124,564
1990	154,109	11,294	51,919	117,832
1991	194,018	4,768	23,989	137,217
1992	142,340	11,251	56,597	124,770
1993	161,686	7,436	34,082	100,830
1994	164,581	3,997	16,618	85,891
1995	56,857	12,079	63,827	32,212
IM Rates	0.017[1]	0.228[2]	0.272[2]	0.272[2]

[1] Drop-off rate from CTC (1997).

[2] Drop-off rate + immediate mortality rate from CTC (1997).

Table II.1.16. Estimated Chinook salmon LIMs and SIMs in the NBC troll fishery, 1985-1995.

Year	LIM CR (Drop-off)	LIM CNR	LIM Total	SIM CR	SIM CNR	SIM Total
1985	2,819	0	2,819	12,405	0	12,405
1986	2,987	0	2,987	19,637	0	19,637
1987	3,017	1,290	4,307	32,450	8,177	40,626
1988	2,590	2,239	4,829	28,364	12,385	40,749
1989	3,531	210	3,740	33,881	1,254	35,135
1990	2,620	2,575	5,195	32,050	14,122	46,172
1991	3,298	1,087	4,385	37,323	6,525	43,848
1992	2,420	2,565	4,985	33,937	15,394	49,332
1993	2,749	1,696	4,444	27,426	9,270	36,696
1994	2,798	911	3,709	23,362	4,520	27,882
1995	967	2,754	3,721	8,762	17,361	26,123

Data from Table II.1.16 were used to construct annual and overall mean ratios of LIM:LC and SIM:LC for the base period, 1985-1995 using equations II.1.1 and II.1.2 (Table II.1.17).

Table II.1.17 Ratios of LIMs and SIMs to LC by year and their averages for the NBC troll fishery, 1985-1995.

Year	LIM:LC	SIM:LC
1985	0.017	0.075
1986	0.017	0.112
1987	0.024	0.229
1988	0.032	0.267
1989	0.018	0.169
1990	0.034	0.300
1991	0.023	0.226
1992	0.035	0.347
1993	0.027	0.227
1994	0.023	0.169
1995	0.065	0.459
$\overline{R}_{LIM_{85-95}}$	0.029	-
$\overline{R}_{SIM_{85-95}}$	-	0.235

II.1.B.2 NBC Sport Fishery

The NBC AABM sport fishery, also known as the Queen Charlotte Island (QCI) sport fishery, occurs in Pacific Fishery Management Areas 1, 2, 101, 102 and 142 around Queen Charlotte Island and north to the border with Alaska (see Figure II.1.2). These areas are also generally referred to as statistical areas 1, 2E and 2W (see CTC 2005). Prior to 1995, the catch in this fishery was relatively low to modest but since then it has increased considerably reaching a peak catch estimate of 74,000 in 2004 (see Table II.1.18 and Table II.1.19).

The Haida Creel Program was first implemented in 1998 and has provided consistent catch and release estimates since 1999. Prior to this program, no data are available concerning release rates of sublegal- and legal-sized fish during the base period years. Haida Creel data from 1999-2008 were employed to construct release estimates to represent the base period. This approach seems reasonable because the general conduct of this fishery has not changed significantly over time. Most of the catch has always occurred during guided trips out of a small number of fishing lodges in relatively remote locations. In addition, fishing has always occurred in the same areas in the summer months and only one minimum size limit has ever been in place (45 cm FL).

The creel data since 1999 and anecdotal reports from fishers suggest that sublegal-sized releases are quite rare in this fishery. We have, therefore, assumed that releases of sublegal-sized fish were non-existent in the base period years (i.e., zero) as they have been in more recent years. It is less certain whether releases of legal-sized fish relative to LC have remained similar over time. Starting in 1992, the bag limit was decreased from four to two fish per day. An increase in legal-sized releases is expected from such a regulation change although factors such as Chinook abundance and the additional time spent fishing by anglers after catching the daily limit can also affect the magnitude of releases. Unfortunately, no data exist to determine whether an increase in the release rate of legal-sized Chinook occurred from 1992 onwards.

Another regulation change implemented in 2001 for one year only could also have increased the release rate of legal-sized fish. This was the use of a slot limit (CTC 2005). Under the slot limit, the same daily bag of two fish was in effect but it could consist only of either two fish within the slot of 45 – 77 cm FL, or, of one fish within the slot and one fish larger than the upper slot limit. Additional fish hooked >77 cm FL were required to be released. To eliminate potential bias associated with such a regulation, 2001 data were not used to estimate legal-sized releases relative to LC for base period.

Examination of legal-sized releases to LC relative to the postseason abundance index (AI-POST) generated by Chinook Model calibration 0907 indicated that releases tend to increase with Chinook abundance in this fishery (Table II.1.18 and Figure II.1.4). A simple linear regression using data from 1999-2000 and 2002-2008 was not significant at $p=0.05$ (legal-sized releases:LC = (0.5826*AI-POST) + 0.0230; $R^2 = 0.36$; $p = 0.09$), nevertheless, this relationship was employed to as a means to estimate legal-sized releases from the landed catch and the AI-POST for each base period year. This was done by entering the AI-POST for a base year into the regression equation, and the resulting release per LC value was then multiplied by the observed catch for that year. Incidental mortalities were calculated in the same manner as for CR troll fisheries, i.e. the estimated legal-sized releases were multiplied by the CTC-accepted release mortality rate and these were added to the drop-off mortalities calculated by multiplying total legal-sized encounters by the fishery-specific drop-off mortality (see Table II.1.20).

Table II.1.18. NBC sport LC, legal-sized releases, the ratio of legal releases to LC and the post-season AI (AI-POST) for the NBC AABM fishery from PSC Chinook Model calibration 0907, 1999-2008. Note that releases below the minimum size limit of 45 cm are rare enough as to be considered zero.

Year	LC	AI-POST	Legal Releases:LC	Legal Releases	Sublegal Releases
1999	30,227	0.95	0.52	15,824	0
2000	22,100	0.94	1.11	24,573	0
2001[1]	30,400	1.21	1.00	30,522	0
2002	47,100	1.70	0.90	42,226	0
2003	54,300	1.91	0.88	47,549	0
2004	74,000	1.80	1.58	116,741	0
2005	68,800	1.55	0.89	60,987	0
2006	64,500	1.24	0.50	32,480	0
2007	61,000	0.98	0.58	35,527	0
2008	43,500	0.93	0.24	10,649	0

[1]Slot limit regulations were employed in 2001.

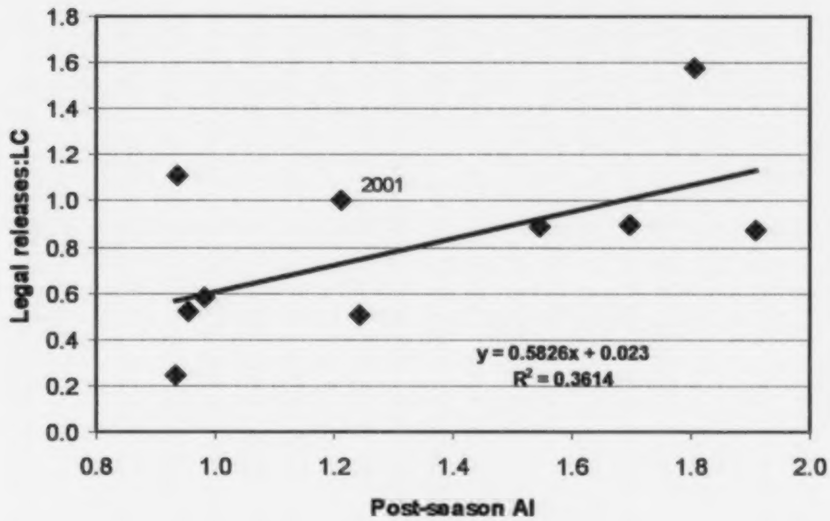

Figure II.1.4. Linear relationship between the post-season AI from PSC Chinook Model calibration 0907 and the ratio of legal-sized releases:LC for NBC sport, 1999-2008. The data point indicated by year 2001 was excluded from the analysis due to the slot limit regulations employed that year.

Table II.1.19. Observed LC for NBC sport, postseason AI (AI-POST) from PSC Chinook Model calibration 0907 and the ratio of legal-sized releases:LC as estimated from simple linear regression (see description in the text and Table II.1.18 for the data employed). The numbers of legal-sized Chinook salmon releases are derived by multiplying the legal-sized releases:LC ratio with observed LC in each base year, 1985-1995.

Year	LC	AI-POST	Legal Releases:LC[4]	Legal Releases	Sublegal Releases
1985	600	1.33	0.795	477	0
1986	1,153	1.48	0.887	1,022	0
1987	2,644	1.76	1.046	2,766	0
1988	7,059	1.87	1.115	7,869	0
1989	20,652	1.70	1.012	20,909	0
1990	16,827	1.66	0.988	16,618	0
1991	15,047	1.53	0.916	13,785	0
1992	21,358	1.41	0.844	18,021	0
1993	25,297	1.43	0.856	21,648	0
1994	28,973	1.26	0.756	21,895	0
1995	22,531	0.98	0.593	13,358	0
IM rates	0.036[1]	--	--	0.159[2]	0.159[3]

[1]Drop-off rate from CTC (1997).

[2]Drop-off rate + immediate mortality rate from CTC (1997).

[3]Drop-off rate + immediate mortality rate from CTC (1997) but Chinook <45 cm, the legal minimum size limit, are rare in this fishery.

[4] The ratio in this column is derived using the equation legal-sized releases:LC = (0.5826*AI-POST) + 0.0230; the legal releases are obtained by multiplying this value by LC.

Table II.1.20. Chinook salmon LIMs and SIMs estimated in the NBC sport fishery, 1985-1995. Encounters with sublegal-sized fish (< 45 cm FL) are rare in this fishery and SIMs are considered to be zero.

Year	LIM Drop-off	LIM CR	LIM Total	SIM Total
1985	39	59	97	0
1986	78	126	204	0
1987	195	340	535	0
1988	537	968	1,505	0
1989	1,496	2,572	4,068	0
1990	1,204	2,044	3,248	0
1991	1,038	1,696	2,733	0
1992	1,418	2,217	3,634	0
1993	1,690	2,663	4,353	0
1994	1,831	2,693	4,524	0
1995	1,292	1,643	2,935	0

Once incidental mortalities were calculated for each base year, ratios of LIM:LC and SIM:LC (Table II.1.21) could then be derived using equations II.1.1 and II.1.2.

Table II.1.21. Estimated ratios of LIMs and SIMs to LC by year and their averages for the NBC sport fishery, 1985-1995.

Year	LIM:LC	SIM:LC
1985	0.162	0.000
1986	0.177	0.000
1987	0.202	0.000
1988	0.213	0.000
1989	0.197	0.000
1990	0.193	0.000
1991	0.182	0.000
1992	0.170	0.000
1993	0.172	0.000
1994	0.156	0.000
1995	0.130	0.000
$\overline{R}_{LIM_{85-95}}$	0.178	-
$\overline{R}_{SIM_{85-95}}$	-	0.000

II.1.C WCVI AABM Incidental Mortality Estimates and 1985-1995 IM Ratios

Methods used to estimate sublegal- and legal-sized Chinook encounters in CNR and CR WCVI troll fisheries and in the WCVI sport fishery for the base period are described in the following sections. Incidental mortalities were calculated from these encounters, and the 1985-1995 average ratio of IM to LC was computed for sublegal-sized and legal-sized Chinook. Overall, the methods used to arrive at these ratios for the WCVI troll and sport fisheries are similar to those employed for the NBC AABM fisheries and are abbreviated in this section as much as possible.

II.1.C.1 WCVI Troll Fishery

The WCVI troll fishery occurs in Pacific Fishery Management Areas 21 and 23-27 (near shore and inlet areas) and 121 and 123-127 (offshore areas seaward of Canada's legal definition of the surf line and seaward of a point-to-point boundary across inlets; see Figure II.1.5). These are referred to informally as statistical areas 21 and 23-27. During the base period years, catch occurred from April – October, with the majority of catch occurring from July – September (Table II.1.22) similar to the temporal distribution noted for NBC troll. Spatially, catch in this fishery was somewhat more evenly distributed across statistical areas relative to NBC troll, though the highest proportion of catch always occurred in area 23 (Figure II.1.6). As with NBC troll, a 62 cm FL size limit was in effect in 1985 and 1986. The size limit was increased to 67 cm FL for the later years in the base period and remained in effect until 1998.

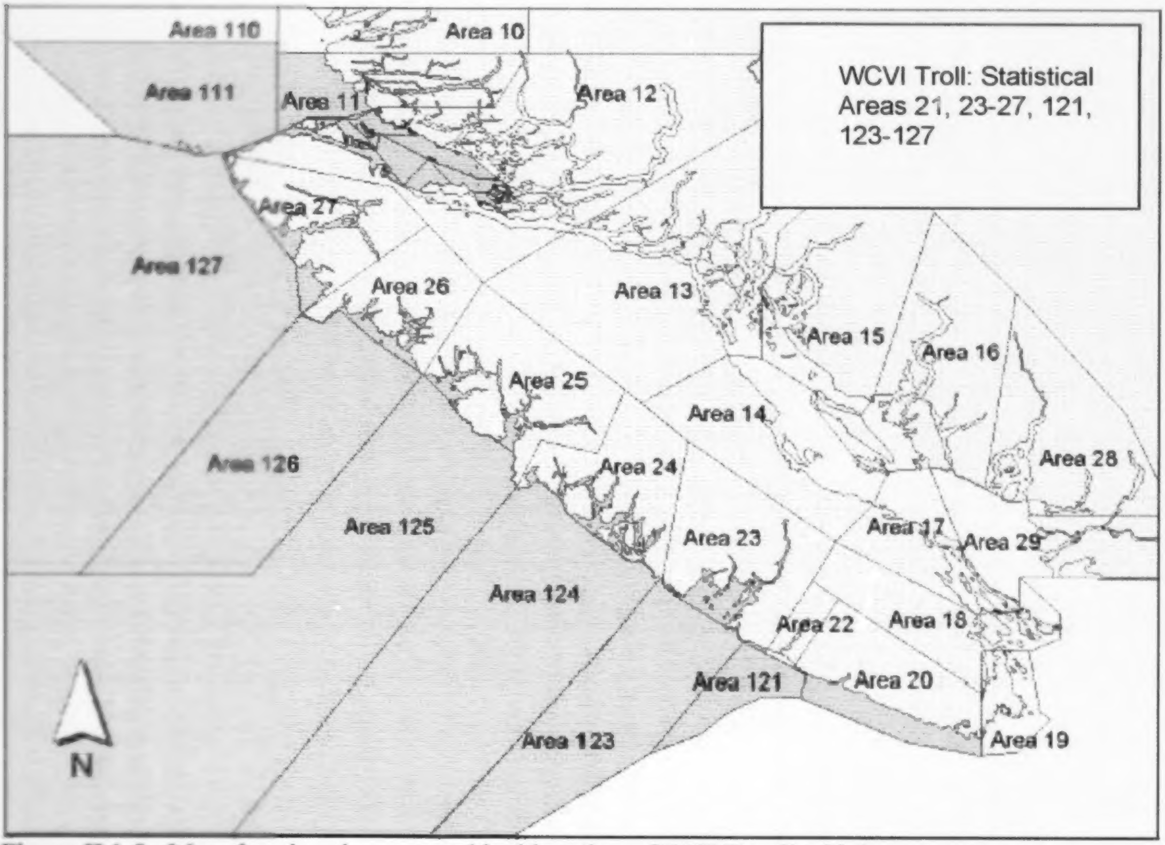

Figure II.1.5. Map showing the geographical location of WCVI troll which encompasses Pacific Fishery Management Areas 21, 23-27, 121, 123-127.

Table II.1.22. Mean percent distribution of WCVI troll catch by statistical area and month, 1985-1995. The bottom row shows the simple average across statistical areas.

Stat Area	Month									
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
21/121	0.0%	0.0%	0.3%	0.0%	57.6%	26.8%	14.2%	1.1%	0.0%	0.0%
23/123	0.0%	0.3%	3.8%	5.1%	64.4%	20.5%	5.6%	0.3%	0.0%	0.0%
24/124	0.0%	0.1%	0.8%	2.3%	65.6%	25.6%	5.3%	0.2%	0.0%	0.0%
25/125	0.0%	0.0%	1.4%	0.7%	53.1%	32.1%	11.4%	1.3%	0.0%	0.0%
26/126	0.0%	0.2%	1.9%	1.2%	52.3%	30.3%	12.8%	1.3%	0.0%	0.0%
27/127	0.0%	0.0%	0.8%	0.7%	47.5%	31.3%	18.8%	1.0%	0.0%	0.0%
Mean	0.0%	0.2%	2.1%	2.7%	58.7%	25.9%	9.9%	0.6%	0.0%	0.0%

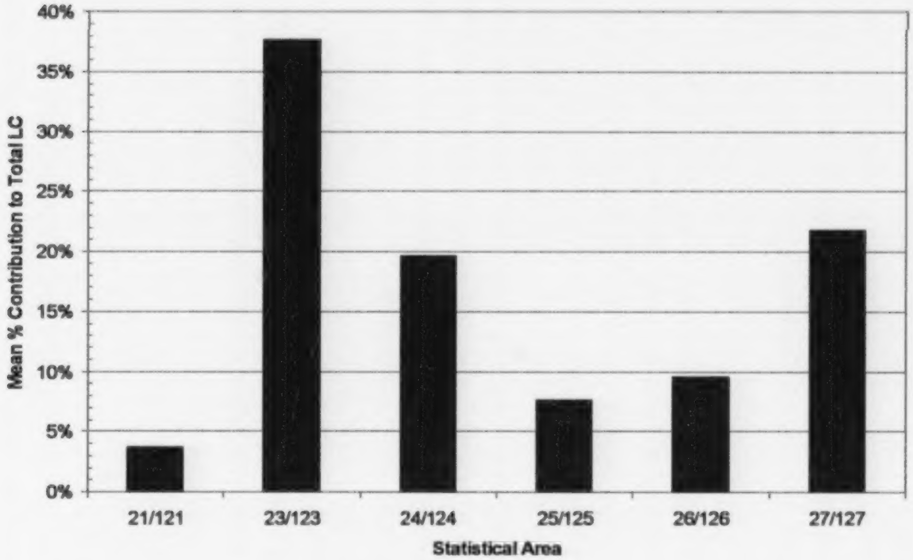

Figure II.1.6. Mean percentage distribution of the WCVI troll catch by statistical area, 1985-1995.

For this fishery, observed encounter data are available from two separate time periods which can be employed to develop LIM:LC and SIM:LC ratios for years in the base period. First, data were collected during WCVI troll openings in the same 1981-1983 encounter rate study used to derive base period ratios for NBC troll (Healey et al. 1985). In addition, several studies to investigate sublegal encounter rates during CR fisheries were conducted between 1987 and 1990 (Olson et al. 1988; Morris and Healey 1990; Waddell et al. 1992; C. McConnell, unpublished data). During these studies vessels were chartered to collect data and thus, fewer vessels were involved compared to the number under the earlier voluntary logbook program. The smaller number of vessels resulted in more sparsely distributed data. Most of the data collected from 1987-1990 was concentrated in the spring period; the only July-August data for this period was collected in 1988. While gaps were present in these data, there were some notable features: they were considered of high quality, they were obtained during the base period, and they provided some means of validating the assumption (required but unsubstantiated in the case of NBC troll) that encounter rates from 1981-1983 period were similar to those in the base period.

For both the pre-base time period and the within-base time period, sublegal-sized Chinook releases and retained legal-sized catch were separately summed across month and area strata. Ratios of sublegal-sized releases to legal-sized LC were then calculated for each stratum in which the total catch exceeded 10 fish. A simple average between the pre-base and within-base encounter ratios was then taken for each stratum. These encounter ratios varied considerably by statistical area and month (see Table II.1.23 and Table II.1.24). There was a tendency to increase from north (area 27) to south (area 21) with much higher rates observed in area 21 compared to all others. Temporally, encounter ratios tended to be higher in the spring and fall, compared to the summer, a somewhat opposite trend to NBC troll.

As for NBC troll, length data collected during the various studies were used to adjust the *number of fish in the 'sublegal-size' category versus the 'legal-size' category.* The adjusted numbers could then be used to derive sublegal encounter rates as if they had occurred under whichever size limit was in effect for that particular year. Strata without observed data were filled using the same un-weighted means ANOVA was employed to fill missing strata with estimates of sublegal encounters rates for NBC troll. Two such sets of sublegal encounter rates were derived, one adjusted to a 62 cm size limit and one to a 67 cm size limit (Table II.1.23 and Table II.1.24). The same procedure as followed for NBC troll was then used to generate annual totals of sublegal encounters for WCVI troll CR fisheries (Table II.1.26).

Table II.1.23. Ratio of sublegal-sized encounters to legal-sized encounters by month and statistical area in WCVI troll under a 62 cm FL size limit. These sublegal encounter rates apply to base period years 1984 and 1985 when a 62 cm minimum size limit was employed. Values in bold font are the adjusted cell means from ANOVA which was used to complete strata with insufficient or no observed data.

Stat Area	Month							
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
21/121	1.417	2.117	1.583	6.759	2.743	4.473	2.639	1.667
23/123	0.996	0.827	0.990	0.387	0.473	1.010	1.560	6.667
24/124	0.622	0.394	0.298	0.617	0.721	3.306	**1.099**	**1.099**
25/125	0.625	0.273	0.175	0.390	0.446	0.556	**0.430**	**0.430**
26/126	0.298	0.333	0.111	0.725	0.545	0.186	**0.430**	**0.430**
27/127	**0.300**	1.143	0.267	0.444	0.125	0.208	**0.430**	**0.430**

Table II.1.24. Ratio of sublegal-sized encounters to legal-sized encounters by month and statistical area in WCVI troll under a 67 cm FL size limit. These sublegal encounter rates apply to base period years 1987-1995 when a 67 cm minimum size limit was employed. Values in bold font are the adjusted cell means from ANOVA which was used to complete strata with insufficient or no observed data.

Stat Area	Month							
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
21/121	3.375	5.509	4.185	12.067	7.090	7.119	3.367	1.667
23/123	2.064	1.999	2.105	0.756	1.146	2.391	1.560	6.667
24/124	1.319	0.718	0.566	1.161	2.445	7.742	**1.860**	**1.860**
25/125	0.715	0.432	0.264	0.663	0.759	0.728	**0.544**	**0.544**
26/126	0.386	0.528	0.316	1.178	0.711	0.402	**0.544**	**0.544**
27/127	**0.402**	1.143	0.425	0.699	0.156	0.289	**0.544**	**0.544**

Casual comparison of the encounter rates between the 1981-1983 and 1987-1990 periods, based on data adjusted to a common size limit of 67 cm, indicated no obvious or systematic differences. While this does not provide definitive evidence that rates did not differ between these time periods, the lack of a systematic pattern suggests that observed variability may be due mainly to annual variation in abundance, or other factors, rather than some fundamental difference in fishing behaviour within the fleet. Consequently, it was deemed appropriate to use data from the pre-base study as well as from the within-base period to estimate sublegal

encounters in CR fisheries for the base period.

Limited CNR fisheries occurred in WCVI troll during the base period. As with NBC troll, no actual sublegal encounter data are available from that period or in adjacent time periods from such fisheries. Chinook model-generated LC, CNR LIM and CNR SIM data from calibration 0907 were used to derive year-specific ratios of LIM:LC and SIM:LIM (Table II.1.25) just as described for NBC troll. The observed LC from each year with CNR periods was multiplied by the model-based LIM:LC ratio to estimate CNR LIMs. These actual LIMs were then multiplied by the model-based LIM:SIM ratio to estimate CNR SIMs (see Table II.1.27). These values could then be expanded by the CTC-accepted size-appropriate release and drop-off mortality rates to calculate encounter estimates (Table II.1.26).

Table II.1.25. Estimates of LIM and SIM in CNR periods, and LC in CR periods, for WCVI troll, 1985-1995, from PSC Chinook Model calibration 0907.

Year	Model LC	LIM	SIM	LIM:LC	SIM:LIM
1985	297,557	1,098	2,854	0.004	2.599
1986	292,819	0	0	0	0
1987	321,217	3,709	14,282	0.012	3.851
1988	346,399	7,324	25,603	0.021	3.496
1989	172,734	0	0	0	0
1990	252,571	0	0	0	0
1991	171,999	0	0	0	0
1992	291,343	0	0	0	0
1993	233,431	0	0	0	0
1994	125,713	0	0	0	0
1995	68,876	4,098	15,754	0.060	3.844

Table II.1.26. Observed LC, estimated number of legal- and sublegal-sized Chinook salmon encounters, and IM rates for the WCVI troll fishery, 1985-1995.

		CNR Periods		CR Periods
Year	LC	Legal	Sublegal	Sublegal
1985	345,937	6,052	13,013	364,739
1986	350,227	0	0	242,922
1987	378,931	20,734	66,071	480,471
1988	408,668	40,948	118,452	503,827
1989	203,751	0	0	232,814
1990	297,858	0	0	336,475
1991	203,035	0	0	309,250
1992	340,146	0	0	351,954
1993	277,033	0	0	310,019
1994	150,039	0	0	280,778
1995	81,454	22,970	73,063	93,228
IM Rates	0.017[1]	0.228[2]	0.272[2]	0.272[2]

[1]Drop-off rate from CTC (1997).

[2]Drop-off rate + immediate mortality rate from CTC (1997).

Estimates of all categories of IM, based on observed data through various approaches, could then be assembled for all years in the base period (Table II.1.27). From these data, ratios of LIM:LC and SIM:LC were constructed (Table II.1.28) using equations II.1.1 and II.1.2.

Table II.1.27. Estimated Chinook salmon LIMs and SIMs in the WCVI troll fishery, 1985-1995.

Year	LIM CR (Drop-off)	LIM CNR	LIM Total	SIM CR	SIM CNR	SIM Total
1985	5,881	1,380	7,261	99,209	3,540	102,749
1986	5,954	0	5,954	66,075	0	66,075
1987	6,442	4,727	11,169	130,688	17,971	148,659
1988	6,947	9,336	16,283	137,041	32,219	169,260
1989	3,464	0	3,464	63,325	0	63,325
1990	5,064	0	5,064	91,521	0	91,521
1991	3,452	0	3,452	84,116	0	84,116
1992	5,782	0	5,782	95,732	0	95,732
1993	4,710	0	4,710	84,325	0	84,325
1994	2,551	0	2,551	76,372	0	76,372
1995	1,385	5,237	6,622	25,358	19,873	45,231

Table II.1.28. Estimated ratios of LIMs and SIMs to LC by year and their averages for the WCVI troll fishery, 1985-1995.

Year	LIM:LC	SIM:LC
1985	0.021	0.297
1986	0.017	0.189
1987	0.029	0.392
1988	0.040	0.414
1989	0.017	0.311
1990	0.017	0.307
1991	0.017	0.414
1992	0.017	0.281
1993	0.017	0.304
1994	0.017	0.509
1995	0.081	0.555
$\overline{R}_{LIM_{85-95}}$	0.026	-
$\overline{R}_{SIM_{85-95}}$	-	0.361

II.1.C.2 WCVI Sport Fishery

The WCVI AABM sport fishery (also known as the WCVI outside sport fishery) occurs in the same statistical areas as the troll fishery (see Figure II.1.5). The portion of the annual fishery considered under AABM provisions is limited to specified times and areas as prescribed in the footnote on p. 52, Chapter 3, of the 2008 PST. Only one minimum size limit (45 cm FL) has been in place in this fishery since 1981.

No observed data are available documenting release rates of sublegal-sized and legal-sized fish for the WCVI sport fishery during the base period. Consequently, more recent estimates of encounters have been employed to develop encounter estimates for the base period similar to the approach used for the NBC sport fishery (section II.1.B.2). A creel program was initiated in 1999 and has since been carried out annually by CDFO staff. Separate estimates of sublegal-sized and legal-sized releases were not generated by this program until 2001. Since then, the WCVI creel program has provided reliable estimates of releases as well as of retained catch (Table II.1.29). The creel program has generally covered the period (June – September) and areas of the highest fishing effort but some fishing activity does occur prior to the start of the creel program and after it concludes. Catch data are also provided by fishing lodges operating throughout the WCVI region. These data are volunteered and unvalidated.

As with the NBC sport fishery, visual inspection of the release data and the AI-POST for the AABM aggregate fishery suggested the possibility of a linearly increasing relationship which could provide a means to estimate releases relative to LC in the base period (Table II.1.29). No useful relationship was found for sublegal-sized releases. Instead, the mean encounter rate of sublegal-sized releases to LC was computed for 2001-2008 (0.240) and the LC in each base year was multiplied by this value to derive an estimate of the sublegal-sized releases (Table II.1.30). A significant linear relationship was found between the legal-sized releases:LC ratio and the AI-POST (legal-sized releases:LC = (0.4138*AI-POST) + 0.0409; $R^2 = 0.61$; $p = 0.04$; see Figure II.1.7). Data from 2002-2008 only were included in the regression analysis due to the fact that a slot limit was employed in 2001. The slot limit regulations required the release of Chinook salmon >77 cm FL with a daily bag allowance of two Chinook from 45 – 77 cm. Area closures were also implemented with all management actions designed to protect returning WCVI Chinook stocks and coho salmon returning to the upper Fraser River. Legal-sized Chinook releases were generated for each base year (Table II.1.30) as previously described for NBC sport (see Section II.1.B.2).

The assumption of similar release rates from the base period years through to more recent years is likely valid for sublegal-sized fish due to the fact that the minimum size limit has not changed over time. The validity of this assumption is more questionable for the legal-sized releases. This stems from persistent conservation concerns for WCVI Chinook salmon stocks which first came to attention in 1995 and resulted in complete troll fishery closures and major restrictions in sport fishing activity in 1996. Those concerns have largely persisted to the present day and have resulted in the implementation of various management actions. Management actions have included the use of the slot limit in 2001, CNR periods in select areas, and the introduction of a one nautical mile 'conservation corridor' extending out from the surf line where either no fishing for Chinook salmon or for any salmon has been permitted in some years. These actions have likely altered behaviour of sport fishers, as well as their encounters with legal-sized Chinook and ultimately, release rates. Nonetheless, the regression function described previously provides a suitable means to estimate legal-sized releases given the absence of any actual data from the base period years.

Table II.1.29. WCVI sport LC, legal-sized and sublegal-sized releases, their ratio with LC and the AI-POST for the WCVI AABM fishery from PSC Chinook Model calibration 0907, 1999-2008. Estimates of legal-sized releases are given for two size categories (from 45-77 cm and >77 cm) due to the use of slot limit regulations in the AABM sport fishery in 2001 and in the ISBM portion of the sport fishery in certain times and areas in other years.

Year	AI-POST	LC	Small Releases (45 – 77 cm)	Large Releases (>77 cm)	Total Legal Releases	Sublegal Releases (<45 cm)	Legal Releases:LC	Sublegal Releases:LC
2001[1]	0.77	40,636	4,922	930	5,852	19,478	0.14	0.48
2002	1.13	31,503	8,006	3,065	11,070	8,762	0.35	0.28
2003	1.19	26,825	10,474	6,604	17,078	12,411	0.64	0.46
2004	0.98	39,086	15,848	2,606	18,454	3,092	0.47	0.08
2005	0.79	50,681	18,416	1,956	20,371	3,522	0.40	0.07
2006	0.62	36,507	12,612	686	13,298	4,633	0.36	0.13
2007	0.53	46,323	6,579	2,918	9,497	12,066	0.21	0.26
2008	0.64	50,556	12,008	2,275	14,283	8,266	0.28	0.16

[1] Slot limit regulations employed in 2001 only.

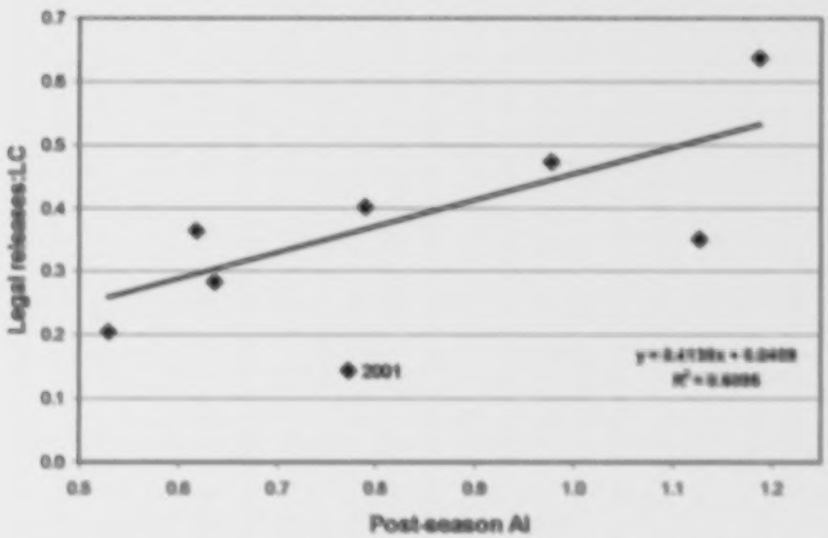

Figure II.1.7. Linear relationship between the AI-POST from PSC Chinook Model calibration 0907 and the ratio of legal-sized releases to LC for WCVI sport, 2001-2008. The data point indicated by year 2001 was excluded from the analysis due to the slot limit regulations employed that year.

Table II.1.30. Total LC, number of legal- and sublegal-sized Chinook salmon releases, and IM rates for the WCVI sport fishery, 1985-1995.

Year	LC	AI-POST	Legal Releases:LC[3]	Legal	Sublegal[4]
1985	23,100	0.99	0.451	10,412	5,543
1986	17,100	1.03	0.467	7,988	4,103
1987	34,800	1.19	0.532	18,505	8,350
1988	12,800	1.13	0.510	6,524	3,071
1989	38,800	0.99	0.450	17,448	9,310
1990	35,000	0.89	0.411	14,388	8,398
1991	39,500	0.75	0.352	13,907	9,478
1992	18,518	0.78	0.363	6,725	4,444
1993	23,312	0.69	0.328	7,655	5,594
1994	10,313	0.52	0.255	2,635	2,475
1995	13,956	0.41	0.212	2,957	3,349
IM Rates	0.069[1]	--	--	0.192[2]	0.192[2]

[1] Drop-off rate from CTC (1997).
[2] Drop-off rate + immediate mortality rate from CTC (1997).
[3] The ratio in this column is derived using the equation legal-sized releases:LC = (0.4138*AI-POST) + 0.0409; the legal releases are obtained by multiplying this value by LC.
[4] Sublegal-sized releases are obtained by multiplying the LC by 0.240.

Incidental mortalities, LIMs and SIMs, were computed from the estimated releases in the same manner as for CR troll fisheries. The release estimates were multiplied by CTC-accepted size-specific release mortality rates and a drop-off mortality rate (Table II.1.30 and Table II.1.31). Ratios of LIM:LC and SIM:LC and their averages for 1985-1995 period were then computed using equations II.1.1 and II.1.2 (Table II.1.32).

Table II.1.31. Estimated Chinook salmon LIMs and SIMs in the WCVI sport fishery, 1985-1995.

Year	LIM Drop-off	LIM CR	LIM Total	SIM Total
1985	2,312	1,281	3,593	1,064
1986	1,731	983	2,714	788
1987	3,678	2,276	5,954	1,603
1988	1,333	802	2,136	590
1989	3,881	2,146	6,027	1,788
1990	3,408	1,770	5,177	1,613
1991	3,685	1,711	5,396	1,820
1992	1,742	827	2,569	853
1993	2,137	942	3,078	1,074
1994	893	324	1,217	475
1995	1,167	364	1,531	643

Table II.1.32. Estimated ratios of LIMs and SIMs to LC by year and their averages for the WCVI sport fishery, 1985-1995.

Year	LIM:LC	SIM:LC
1985	0.156	0.046
1986	0.159	0.046
1987	0.171	0.046
1988	0.167	0.046
1989	0.155	0.046
1990	0.148	0.046
1991	0.137	0.046
1992	0.139	0.046
1993	0.132	0.046
1994	0.118	0.046
1995	0.110	0.046
$\overline{R}_{LIM_{85-95}}$	0.145	-
$\overline{R}_{SIM_{85-95}}$	-	0.046

II.2 COMPUTATION OF LC EQUIVALENCIES AND TM LIMITS FOR TABLE 1

Conversion of Table 1 from LC to TM limits involves three sets of information: (1) a metric to equate SIMs to LCEs of legal-sized fish within gear types; (2) a metric to represent LCEs for gear types in a common currency, TCEs; and (3) estimates of incidental mortalities associated with LC. This information was then applied in the following sequence:

1. For each AI in Table 1, LC was allocated between gear types of each fishery according to the allocation assumptions underlying Table 1.
2. For each AABM fishery, base period (1985-1995) average LIM:LC and SIM:LC ratios for each gear were used to calculate LIMs and SIMs associated with LC of each gear.
3. Model AEQs (calibration 0907) were used to calculate base period average AEQs for legal and sublegal fish caught by each gear type in each AABM fishery.
4. The ratio of base period average sublegal AEQ to average legal AEQ was used to convert SIMs into LCEs for each gear type.
5. For each fishery, LC, LIMs and SIMs for sport (and net in SEAK) were converted to TCEs based on the ratio of base period average legal AEQs for a gear sector to base period average AEQs for the troll gear sector.
6. TCEs were combined into a revised Table 1 format.

II.2.A AEQ Method of Calculating LCEs

II.2.A.1 Calculation of Average Sector- and Size-Specific AEQ Factors

Average AEQs are used to convert incidental mortalities into LCEs within gear types. The CTC has defined an AEQ as the probability a fish would survive to reach its terminal area in the absence of fishing in the current and all future years, thus taking into account the age- and stock-specific maturation schedule.

For the current year, the probability that a fish would survive to reach its terminal area in the absence of fishing is simply the maturation rate:

$$AEQ_{s,a,y} = MR_{s,a} \qquad \text{(Equation II.2.1)}$$

where s is stock, a is age, y is year, and MR is maturation rate.

The probability that the fish would survive to reach a terminal area in the next year in the absence of fishing is

$$AEQ_{s,a,y+1} = (1 - MR_{s,a}) * S_{a+1} * MR_{s,a+1} \qquad \text{(Equation II.2.2)}$$

where S is the pre-fishing natural survival rate. The total AEQ over all years is then

$$\sum_{i=0}^{5-a} AEQ_{s,a,y+i} \qquad \text{(Equation II.2.3)}$$

Within a gear type (troll, sport, or net), AEQs can be computed for both sublegal and legal-sized fish. For a given gear type, the average AEQs for legal-sized fish is:

$$\overline{AEQ}_{f,L} = \frac{\sum_{s}\sum_{a}\sum_{y=85}^{95} AEQ_{s,a} * Catch_{s,a,f,y,L}}{\sum_{s}\sum_{a}\sum_{y=85}^{95} Catch_{s,a,f,y,L}} \qquad \text{(Equation II.2.4)}$$

and for sublegal-sized fish as:

$$\overline{AEQ}_{f,SL} = \frac{\sum_{s}\sum_{a}\sum_{y=85}^{95} AEQ_{s,a} * IM_{s,a,f,y,SL}}{\sum_{s}\sum_{a}\sum_{y=85}^{95} IM_{s,a,f,y,SL}} \qquad \text{(Equation II.2.5)}$$

where f is fishery, L are legal-sized fish, and SL are sublegal. The LCE of a sublegal-sized fish is defined as the ratio of sublegal to legal average AEQs:

$$LCE_f = \frac{\overline{AEQ}_{f,a}}{\overline{AEQ}_{f,L}} \quad \text{(Equation II.2.6)}$$

Stock and age compositions of the catch and incidental mortalities are produced by the PSC Chinook Model from estimates of cohort sizes, stock-age-fishery-specific exploitation rates, and proportion of each stock-age that are believed vulnerable to the gear (PVs).

II.2.A.2 Conversion to a Common Currency - Troll Catch Equivalents

LCEs are gear-specific. This is because there may be differences in stock and age compositions of the catch in sport fisheries compared to troll fisheries resulting from differences in where and when fishing occurs or from differences in regulations (e.g., minimum size limits may be smaller for sport fisheries than troll fisheries). A means to equate gear-sector LCEs to a common currency was necessary. Because the harvest rate index in Appendix B to Annex IV, Chapter 3 of the 2008 Agreement is defined in terms of the troll LC, the average AEQs were used to develop TCEs:

$$TCE_i = \frac{\overline{AEQ}_{f,L}}{\overline{AEQ}_{f(t),L}} \quad \text{(Equation II.2.7)}$$

where t is the troll sector within an AABM fishery.

II.2.A.3 Estimation of IM of Legal- and Sublegal-Sized Chinook

The LC limits in Table 1 of the 2008 Agreement reflect allocations of LC among gear sectors as per Appendix B to Annex IV, Chapter 3. LIMs and SIMs for each gear sector were estimated for each AI by multiplying the average LIM:LC and SIM:LC ratios by allocated LC limits for each sector. LIMs, SIMs, and LCs in the sport fisheries and in the SEAK net fishery were then converted into TCEs as described above. Procedures to estimate average LIM:LC and SIM:LC ratios are described for individual AABM fisheries in sections II.2.B-D.

II.2.B SEAK AABM Fishery

For SEAK, the underlying relationship in Appendix B to Annex IV, Chapter 3, allocates 17,000 fish to net and, of the remainder, 80% to troll and 20% to sport. The LIM:LC and SIM:LC average ratios for SEAK are presented in Table II.2.1. These ratios are multiplied by the LC associated with a given AI for SEAK in Table 1 of the 2008 Agreement to estimate TM, expressed in nominal numbers of fish (Panel A, Table II.2.2). For example, LIMs were estimated by multiplying the troll LC for a given AI by 0.102.

Table II.2.1. Average ratios of LIM:LC and SIM:LC for SEAK troll, sport and net gear sectors for the 1985-1995 base period, extracted from Table II.1.3, Table II.1.6 and Table II.1.9.

Ratio Statistic	Gear Sector		
	Troll	Sport	Net
LIM:LC	0.102	0.093	0.274
SIM:LC	0.237	0.169	1.171

Table II.2.2. Panel A for developing the proposed Table 1 with TM limits for SEAK, expressed in nominal numbers of fish. Allocation of fish at selected AIs amongst all gear sectors (g) as per the underlying relationship in Table 1 of the 2008 Agreement, which is 17,000 LC to net (n), and the remainder 80% troll (t) and 20% sport (s), multiplied by the gear- and size-specific ratios in Table II.1.1. (Rounding to three digits in Table II.2.1 results in minor rounding errors if these numbers are used to recreate the LIM and SIM values below.)

	Totals in Nominal Numbers			Troll			Sport			Net		
AI	LC_g	LIM_g	SIM_g	LC_t	LIM_t	SIM_t	LC_s	LIM_s	SIM_s	LC_n	LIM_n	SIM_n
0.30	50,200	7,976	27,325	26,560	2,698	6,299	6,640	618	1,123	17,000	4,660	19,904
0.40	61,200	9,075	29,784	35,360	3,591	8,386	8,840	823	1,495	17,000	4,660	19,904
0.495	71,700	10,124	32,131	43,760	4,445	10,378	10,940	1,019	1,850	17,000	4,660	19,904
0.50	72,300	10,184	32,265	44,240	4,493	10,492	11,060	1,030	1,870	17,000	4,660	19,904
0.60	83,300	11,282	34,724	53,040	5,387	12,578	13,260	1,235	2,242	17,000	4,660	19,904
0.70	94,400	12,391	37,205	61,920	6,289	14,684	15,480	1,441	2,617	17,000	4,660	19,904
0.80	105,400	13,489	39,664	70,720	7,183	16,771	17,680	1,646	2,989	17,000	4,660	19,904
0.90	116,500	14,598	42,146	79,600	8,085	18,877	19,900	1,853	3,365	17,000	4,660	19,904
1.00	127,500	15,697	44,604	88,400	8,979	20,964	22,100	2,058	3,737	17,000	4,660	19,904
1.005	128,700	15,817	44,873	89,360	9,076	21,192	22,340	2,080	3,777	17,000	4,660	19,904
1.05	139,600	16,905	47,309	98,080	9,962	23,260	24,520	2,283	4,146	17,000	4,660	19,904
1.10	151,700	18,114	50,014	107,760	10,945	25,555	26,940	2,508	4,555	17,000	4,660	19,904
1.20	176,000	20,541	55,446	127,200	12,920	30,166	31,800	2,961	5,377	17,000	4,660	19,904
1.205	199,800	22,918	60,766	146,240	14,853	34,681	36,560	3,404	6,181	17,000	4,660	19,904
1.30	214,200	24,356	63,985	157,760	16,023	37,413	39,440	3,672	6,668	17,000	4,660	19,904
1.40	229,400	25,874	67,383	169,920	17,259	40,297	42,480	3,955	7,182	17,000	4,660	19,904
1.50	244,600	27,392	70,780	182,080	18,494	43,180	45,520	4,238	7,696	17,000	4,660	19,904
1.505	264,400	29,370	75,206	197,920	20,102	46,937	49,480	4,607	8,366	17,000	4,660	19,904
1.60	280,000	30,928	78,694	210,400	21,370	49,897	52,600	4,898	8,893	17,000	4,660	19,904
1.70	296,400	32,566	82,359	223,520	22,703	53,008	55,880	5,203	9,448	17,000	4,660	19,904
1.80	312,900	34,214	86,048	236,720	24,043	56,138	59,180	5,510	10,006	17,000	4,660	19,904
1.90	329,300	35,852	89,714	249,840	25,376	59,250	62,460	5,816	10,560	17,000	4,660	19,904
2.00	345,700	37,490	93,380	262,960	26,708	62,361	65,740	6,121	11,115	17,000	4,660	19,904
2.10	362,200	39,138	97,068	276,160	28,049	65,492	69,040	6,428	11,673	17,000	4,660	19,904
2.20	378,600	40,776	100,734	289,280	29,382	68,603	72,320	6,734	12,227	17,000	4,660	19,904
2.25	386,800	41,595	102,567	295,840	30,048	70,159	73,960	6,886	12,505	17,000	4,660	19,904

Average AEQ values for legal- and sublegal-sized Chinook salmon in the SEAK fisheries for the IM base period of 1985-1995 are shown in Table II.2.3. These AEQs are estimated from the output files of calibration 0907 produced by the PSC Chinook Model. Annual AEQ factors varied during this period because of differences in estimated stock-age compositions of LC, LIMs, and SIMs. The coefficient of variation (CVs) of AEQ values indicated relative stability over the time series. The CVs were < 1.0% for legal-sized sport and troll, and between 2.2% and 2.4% for net legal-sized fish and troll and sport sublegal-sized fish. The sport AEQ average for sublegal-sized fish was used for SEAK net sublegal-sized fish because the average AEQ of 0.836 for net from calibration 0907 is almost as large as the legal net AEQ, and is inconsistent with CWTs, length, age and maturity data for SEAK net SIM. This substitution is conservative and precautionary in that it has the effect of lowering the total TM limit for SEAK.

Table II.2.3. AEQs for legal- and sublegal-sized fish in SEAK from PSC Chinook Model calibration 0907 for troll (T), sport (S) and net (N) sectors, 1985-1995.

	AEQs of legal-sized fish			AEQs of sublegal-sized fish		
YEAR	SEAK T	SEAK S	SEAK N	SEAK T	SEAK S	SEAK N
1985	0.925	0.897	0.830	0.687	0.662	*0.764*
1986	0.917	0.899	0.824	0.665	0.641	*0.836*
1987	0.920	0.895	0.804	0.703	0.673	*0.816*
1988	0.940	0.914	0.838	0.666	0.642	*0.851*
1989	0.930	0.900	0.832	0.696	0.668	*0.843*
1990	0.921	0.897	0.839	0.675	0.649	*0.848*
1991	0.935	0.899	0.857	0.682	0.654	*0.859*
1992	0.931	0.897	0.864	0.677	0.649	*0.863*
1993	0.924	0.903	0.866	0.717	0.688	*0.857*
1994	0.942	0.908	0.871	0.671	0.647	*0.877*
1995	0.929	0.885	0.855	0.682	0.656	*0.777*
AVG	**0.928**	**0.899**	**0.844**	**0.684**	**0.657**	**0.657** [1]
SD	0.008	0.007	0.021	0.016	0.015	
CV	0.9%	0.8%	2.4%	2.3%	2.2%	

[1] The average AEQ values for SEAK net sublegal-sized fish (shown in italics) were unrealistically high (AVG=0.836) so the AEQs for SEAK sport sublegal-sized fish were deemed an appropriate surrogate; hence the identical numbers for AVG AEQ for sport and net sublegal-sized fish.

The 1985-1995 average AEQ values by size group and gear were used to develop the average AEQs for sublegal and legal Chinook within a gear sector (Table II.2.4). The ratio of these average AEQs were used to compute the LCE_f according to Equation II.2.6 (Table II.2.4), which in turn was used to convert nominal numbers of sublegal-sized fish in Table II.2.2 to LCEs within each gear type (Panel B, Table II.2.5).

Table II.2.4. Average AEQs for legal- and sublegal-sized fish in SEAK for 1985-1995, and the LCE_f (= ratio of average AEQ_{SL} to average AEQ_L).

AEQ Statistic	Troll	Sport	Net
$AEQ_{f,L}$	0.928	0.899	0.844
$AEQ_{f,SL}$	0.684	0.657	0.657
LCE_f	0.736	0.731	0.779

Table II.2.5. Panel B for developing the- proposed Table 1 with TM limits for SEAK, expressed in gear-specific LCEs, at selected AIs.

	Totals in Gear-Specific LCEs			Troll LCEs			Sport LCEs			Net LCEs		
AI	LC_g	LIM_g	SIM_g	LC_t	LIM_t	SIM_t	LC_s	LIM_s	SIM_s	LC_n	LIM_n	SIM_n
0.30	50,200	7,976	20,962	26,560	2,698	4,639	6,640	618	820	17,000	4,660	15,503
0.40	61,200	9,075	22,770	35,360	3,591	6,176	8,840	823	1,092	17,000	4,660	15,503
0.495	71,700	10,124	24,497	43,760	4,445	7,643	10,940	1,019	1,351	17,000	4,660	15,503
0.50	72,300	10,184	24,595	44,240	4,493	7,726	11,060	1,030	1,366	17,000	4,660	15,503
0.60	83,300	11,282	26,404	53,040	5,387	9,263	13,260	1,235	1,638	17,000	4,660	15,503
0.70	94,400	12,391	28,229	61,920	6,289	10,814	15,480	1,441	1,912	17,000	4,660	15,503
0.80	105,400	13,489	30,038	70,720	7,183	12,351	17,680	1,646	2,184	17,000	4,660	15,503
0.90	116,500	14,598	31,863	79,600	8,085	13,902	19,900	1,853	2,458	17,000	4,660	15,503
1.00	127,500	15,697	33,672	88,400	8,979	15,439	22,100	2,058	2,730	17,000	4,660	15,503
1.005	128,700	15,817	33,869	89,360	9,076	15,607	22,340	2,080	2,759	17,000	4,660	15,503
1.05	139,600	16,905	35,661	98,080	9,962	17,130	24,520	2,283	3,029	17,000	4,660	15,503
1.10	151,700	18,114	37,651	107,760	10,945	18,820	26,940	2,508	3,328	17,000	4,660	15,503
1.20	176,000	20,541	41,646	127,200	12,920	22,215	31,800	2,961	3,928	17,000	4,660	15,503
1.205	199,800	22,918	45,559	146,240	14,853	25,541	36,560	3,404	4,516	17,000	4,660	15,503
1.30	214,200	24,356	47,927	157,760	16,023	27,553	39,440	3,672	4,872	17,000	4,660	15,503
1.40	229,400	25,874	50,426	169,920	17,259	29,676	42,480	3,955	5,247	17,000	4,660	15,503
1.50	244,600	27,392	52,925	182,080	18,494	31,800	45,520	4,238	5,623	17,000	4,660	15,503
1.505	264,400	29,370	56,181	197,920	20,102	34,566	49,480	4,607	6,112	17,000	4,660	15,503
1.60	280,000	30,928	58,746	210,400	21,370	36,746	52,600	4,898	6,497	17,000	4,660	15,503
1.70	296,400	32,566	61,443	223,520	22,703	39,037	55,880	5,203	6,902	17,000	4,660	15,503
1.80	312,900	34,214	64,156	236,720	24,043	41,343	59,180	5,510	7,310	17,000	4,660	15,503
1.90	329,300	35,852	66,852	249,840	25,376	43,634	62,460	5,816	7,715	17,000	4,660	15,503
2.00	345,700	37,490	69,549	262,960	26,708	45,926	65,740	6,121	8,120	17,000	4,660	15,503
2.10	362,200	39,138	72,262	276,160	28,049	48,231	69,040	6,428	8,528	17,000	4,660	15,503
2.20	378,600	40,776	74,958	289,280	29,382	50,522	72,320	6,734	8,933	17,000	4,660	15,503
2.25	386,800	41,595	76,306	295,840	30,048	51,668	73,960	6,886	9,136	17,000	4,660	15,503

The base period average $AEQ_{f,L}$ to base period average $AEQ_{f(0),L}$ for the troll gear sector was used to calculate scalars for converting to TCEs based on equation II.2.7. (Table II.2.6). These scalars were then used to convert within-gear LCEs in Table II.2.5 to TCEs (Panel C, Table II.2.7). For each AI, the LC limit is depicted in the second column and the TM limit expressed in TCEs is depicted in the third column. Table II.2.7 presents the allocation of TCEs by sector according to the underlying allocation for Table 1 of the 2008 Agreement.

Table II.2.6. Scalars for converting sport and net gear-specific LCEs to TCEs for the 1985-1995 base period.

Gear Sector	TCE Scalar
Troll	1.00
Sport	0.97
Net	0.91

Table II.2.7. Panel C for development of the proposed Table 1 with TM limits for SEAK, expressed in TCEs, at selected AIs.

		Total TM in	Totals in TCEs			Troll			Sport in TCEs			Net in TCEs		
AI	LC	TCEs	LC_g/t	LIM_g/t	SIM_g/t	LC_t	LIM_t	SIM_t	LC_s/t	LIM_s/t	SIM_s/t	LC_n/t	LIM_n/t	SIM_n/t
0.30	50,200	75,490	48,439	7,531	19,520	26,560	2,698	4,639	6,432	599	795	15,447	4,235	14,086
0.40	61,200	89,314	59,370	8,623	21,320	35,360	3,591	6,176	8,564	797	1,058	15,447	4,235	14,086
0.495	71,700	102,509	69,805	9,666	23,038	43,760	4,445	7,643	10,598	987	1,309	15,447	4,235	14,086
0.50	72,300	103,263	70,401	9,726	23,136	44,240	4,493	7,726	10,714	998	1,323	15,447	4,235	14,086
0.60	83,300	117,086	81,332	10,818	24,936	53,040	5,387	9,263	12,845	1,196	1,587	15,447	4,235	14,086
0.70	94,400	131,036	92,363	11,920	26,753	61,920	6,289	10,814	14,996	1,396	1,852	15,447	4,235	14,086
0.80	105,400	144,859	103,294	13,012	28,553	70,720	7,183	12,351	17,127	1,595	2,116	15,447	4,235	14,086
0.90	116,500	158,809	114,325	14,114	30,370	79,600	8,085	13,902	19,278	1,795	2,381	15,447	4,235	14,086
1.00	127,500	172,632	125,256	15,207	32,170	88,400	8,979	15,439	21,409	1,993	2,644	15,447	4,235	14,086
1.005	128,700	174,140	126,448	15,326	32,366	89,360	9,076	15,607	21,641	2,015	2,673	15,447	4,235	14,086
1.05	139,600	187,838	137,280	16,408	34,150	98,080	9,962	17,130	23,753	2,212	2,934	15,447	4,235	14,086
1.10	151,700	203,044	149,304	17,610	36,130	107,760	10,945	18,820	26,098	2,430	3,224	15,447	4,235	14,086
1.20	176,000	233,582	173,452	20,022	40,107	127,200	12,920	22,215	30,806	2,868	3,805	15,447	4,235	14,086
1.205	199,800	263,491	197,104	22,386	44,002	146,240	14,853	25,541	35,417	3,298	4,375	15,447	4,235	14,086
1.30	214,200	281,587	211,414	23,815	46,358	157,760	16,023	27,553	38,207	3,557	4,719	15,447	4,235	14,086
1.40	229,400	300,689	226,519	25,325	48,846	169,920	17,259	29,676	41,152	3,832	5,083	15,447	4,235	14,086
1.50	244,600	319,791	241,623	26,834	51,333	182,080	18,494	31,800	44,097	4,106	5,447	15,447	4,235	14,086
1.505	264,400	344,673	261,300	28,800	54,574	197,920	20,102	34,566	47,933	4,463	5,921	15,447	4,235	14,086
1.60	280,000	364,278	276,802	30,349	57,127	210,400	21,370	36,746	50,955	4,744	6,294	15,447	4,235	14,086
1.70	296,400	384,887	293,100	31,977	59,810	223,520	22,703	39,037	54,133	5,040	6,686	15,447	4,235	14,086
1.80	312,900	405,623	309,496	33,616	62,511	236,720	24,043	41,343	57,330	5,338	7,081	15,447	4,235	14,086
1.90	329,300	426,233	325,794	35,244	65,194	249,840	25,376	43,634	60,507	5,634	7,474	15,447	4,235	14,086
2.00	345,700	446,842	342,091	36,873	67,878	262,960	26,708	45,926	63,684	5,930	7,866	15,447	4,235	14,086
2.10	362,200	467,578	358,488	38,511	70,579	276,160	28,049	48,231	66,881	6,227	8,261	15,447	4,235	14,086
2.20	378,600	488,187	374,785	40,139	73,262	289,280	29,382	50,522	70,059	6,523	8,654	15,447	4,235	14,086
2.25	386,800	498,492	382,934	40,954	74,604	295,840	30,048	51,668	71,647	6,671	8,850	15,447	4,235	14,086

II.2.C NBC AABM Fishery

The approach used for the NBC AABM fishery to derive an estimate of TM at each AI for a TM version of Table 1 followed essentially the same steps as described for the SEAK AABM fishery. The LC at each AI in the LC version of Table 1 was multiplied by the LIM:LC and SIM:LC ratios to obtain estimates of LIMs and SIMs in nominal fish (Table II.2.9). LC was partitioned into each gear sector using the allocation of 80% troll and 20% sport assumed in Table 1 under the 2008 Agreement.

Table II.2.8. Average ratios of LIM:LC and SIM:LC for NBC troll and sport for the 1985-1995 base period, extracted from Table II.1.17 and Table II.1.21.

Ratio Statistic	Gear Sector	
	Troll	Sport
LIM:LC	0.029	0.178
SIM:LC	0.235	0.000[1]

[1] The SIM:LC ratio is zero due to the lack of sublegal-sized encounters (<45 cm) in NBC sport.

Table II.2.9. Panel A for developing the proposed Table 1 with TM limits for NBC, expressed in nominal numbers of fish. Allocation of fish at selected AIs amongst all gear sectors (g) as per the underlying relationship in Table 1 of the 2008 Agreement, which is 80% troll (t) and 20% sport (s), multiplied by the gear- and size-specific ratios in Table II.2.8. (The values in Table II.2.8 have been rounded to three digits; unrounded values were used to compute the LIM and SIM values below.)

	Nominal Totals			Troll			Sport		
AI	LC_g	LIM_g	SIM_g	LC_t	LIM_t	SIM_t	LC_s	LIM_s	SIM_s
0.30	39,000	2,279	7,318	31,200	893	7,318	7,800	1,386	0
0.40	52,000	3,039	9,757	41,600	1,190	9,757	10,400	1,849	0
0.495	64,400	3,764	12,084	51,520	1,474	12,084	12,880	2,289	0
0.50	65,000	3,799	12,197	52,000	1,488	12,197	13,000	2,311	0
0.60	78,000	4,559	14,636	62,400	1,786	14,636	15,600	2,773	0
0.70	91,000	5,318	17,076	72,800	2,083	17,076	18,200	3,235	0
0.80	104,000	6,078	19,515	83,200	2,381	19,515	20,800	3,697	0
0.90	117,000	6,838	21,954	93,600	2,678	21,954	23,400	4,159	0
1.00	130,000	7,598	24,394	104,000	2,976	24,394	26,000	4,622	0
1.005	130,700	7,639	24,525	104,560	2,992	24,525	26,140	4,647	0
1.05	136,500	7,978	25,613	109,200	3,125	25,613	27,300	4,853	0
1.10	143,000	8,357	26,833	114,400	3,274	26,833	28,600	5,084	0
1.20	156,000	9,117	29,272	124,800	3,571	29,272	31,200	5,546	0
1.205	156,700	9,158	29,404	125,360	3,587	29,404	31,340	5,571	0
1.30	170,700	9,976	32,031	136,560	3,908	32,031	34,140	6,069	0
1.40	185,300	10,830	34,770	148,240	4,242	34,770	37,060	6,588	0
1.50	200,000	11,689	37,529	160,000	4,578	37,529	40,000	7,110	0
1.505	219,600	12,834	41,207	175,680	5,027	41,207	43,920	7,807	0
1.60	233,400	13,641	43,796	186,720	5,343	43,796	46,680	8,298	0
1.70	248,000	14,494	46,536	198,400	5,677	46,536	49,600	8,817	0
1.80	262,600	15,347	49,275	210,080	6,012	49,275	52,520	9,336	0
1.90	277,200	16,201	52,015	221,760	6,346	52,015	55,440	9,855	0
2.00	291,800	17,054	54,755	233,440	6,680	54,755	58,360	10,374	0
2.10	306,400	17,907	57,494	245,120	7,014	57,494	61,280	10,893	0
2.20	321,000	18,760	60,234	256,800	7,348	60,234	64,200	11,412	0
2.25	328,300	19,187	61,604	262,640	7,516	61,604	65,660	11,671	0

Estimates of SIMs were then converted to their LCEs using average AEQs. Data resulting from calibration 0907 of the PSC Chinook Model were used to derive the average AEQ values as described generally in Section II.2.A.1 and specifically for SEAK AABM fisheries in Section II.2.B. Annual values calculated for legal-sized and sublegal-sized fish for the base period years as well the overall average for NBC troll (Table II.2.10 and Table II.2.11) were reasonably similar to those for SEAK troll (see Table II.2.4). Annual and overall average values for either size category of fish in NBC sport appeared unrealistic and underscored recognized problems in the generation of incidental mortalities for this fishery by the Model. First, the Model generated SIMs for NBC sport when in reality sublegal-sized fish are rarely encountered. Second, AEQ values for legal-sized fish were notably smaller than values for both SEAK sport and WCVI sport (see Table II.2.17 for WCVI sport). Given the large size of Chinook salmon encountered in the trophy NBC sport fishery, the expected average AEQ value should exceed that for WCVI sport.

A substitute average AEQ value for legal-sized fish caught in NBC sport was computed using the average AEQ for legal-sized caught in NBC troll. The troll value was multiplied by the average of two other ratios – average AEQ in SEAK sport:average AEQ in SEAK troll and average AEQ in WCVI sport:average AEQ in WCVI troll. This resulted in a value for legal-sized fish that was somewhat lower than the average values for the other two AABM sport fisheries but within an acceptable range (Table II.2.11). A substitute value was computed in the same way for sublegal-sized fish even though this was not necessary given the absence of SIMs in the fishery.

Table II.2.10. Average AEQs for legal and sublegal sized Chinook in NBC from PSC Chinook Model calibration 0907 for troll (T) and sport (S) sectors, 1985-1995.

	Average AEQs of legal-sized fish		AverageAEQs of sublegal-sized fish	
Year	NBC T	NBC S[1]	NBC T	NBC S[1]
1985	0.864	0.654	0.662	0.589
1986	0.870	0.656	0.640	0.585
1987	0.885	0.658	0.706	0.580
1988	0.903	0.664	0.675	0.586
1989	0.884	0.654	0.701	0.584
1990	0.892	0.644	0.684	0.584
1991	0.897	0.645	0.689	0.584
1992	0.894	0.650	0.684	0.578
1993	0.892	0.653	0.723	0.589
1994	0.915	0.632	0.682	0.589
1995	0.901	0.634	0.687	0.595
Mean	0.891	0.649	0.685	0.586
SD	0.015	0.010	0.022	0.005
CV	1.7%	1.5%	3.2%	0.8%

[1] These AEQ values are from calibration 0907 but are not deemed representative of true values for this fishery as described in the text.

Table II.2.11. Average AEQs for legal-sized (LC) and sublegal-sized (SL) Chinook in NBC troll and NBC sport for 1985-1995 and the ratio of average sublegal AEQ to average legal AEQ (i.e., the LCE scalar).

AEQ Statistic	Troll	Sport[1]
$AEQ_{f,L}$	0.891	0.872
$AEQ_{f,SL}$	0.685	0.620
LCE_f	0.769	0.711

[1] Modified average AEQ values for the NBC sport fishery are given here but given the absence of sublegal-sized fish in this fishery, no conversion of sport SIMs to sport LCEs is necessary.

The SIMs in NBC troll converted to LCEs are shown in Table II.2.12. Values differ in only two columns of Table II.2.12 compared to Table II.2.9. These are SIM_t under Troll and SIM_g under Nominal Totals.

Table II.2.12. Panel B for developing the proposed Table 1 with TM limits for NBC, expressed in gear-specific LCEs at selected AIs.

	Totals in Gear LCEs			Troll LCEs			Sport LCEs		
AI	LC_g	LIM_g	SIM_g	LC_t	LIM_t	SIM_t	LC_s	LIM_s	SIM_s
0.30	39,000	2,279	5,626	31,200	893	5,626	7,800	1,386	0
0.40	52,000	3,039	7,502	41,600	1,190	7,502	10,400	1,849	0
0.495	64,400	3,764	9,291	51,520	1,474	9,291	12,880	2,289	0
0.50	65,000	3,799	9,377	52,000	1,488	9,377	13,000	2,311	0
0.60	78,000	4,559	11,253	62,400	1,786	11,253	15,600	2,773	0
0.70	91,000	5,318	13,128	72,800	2,083	13,128	18,200	3,235	0
0.80	104,000	6,078	15,003	83,200	2,381	15,003	20,800	3,697	0
0.90	117,000	6,838	16,879	93,600	2,678	16,879	23,400	4,159	0
1.00	130,000	7,598	18,754	104,000	2,976	18,754	26,000	4,622	0
1.005	130,700	7,639	18,855	104,560	2,992	18,855	26,140	4,647	0
1.05	136,500	7,978	19,692	109,200	3,125	19,692	27,300	4,853	0
1.10	143,000	8,357	20,630	114,400	3,274	20,630	28,600	5,084	0
1.20	156,000	9,117	22,505	124,800	3,571	22,505	31,200	5,546	0
1.205	156,700	9,158	22,606	125,360	3,587	22,606	31,340	5,571	0
1.30	170,700	9,976	24,626	136,560	3,908	24,626	34,140	6,069	0
1.40	185,300	10,830	26,732	148,240	4,242	26,732	37,060	6,588	0
1.50	200,000	11,689	28,853	160,000	4,578	28,853	40,000	7,110	0
1.505	219,600	12,834	31,680	175,680	5,027	31,680	43,920	7,807	0
1.60	233,400	13,641	33,671	186,720	5,343	33,671	46,680	8,298	0
1.70	248,000	14,494	35,778	198,400	5,677	35,778	49,600	8,817	0
1.80	262,600	15,347	37,884	210,080	6,012	37,884	52,520	9,336	0
1.90	277,200	16,201	39,990	221,760	6,346	39,990	55,440	9,855	0
2.00	291,800	17,054	42,096	233,440	6,680	42,096	58,360	10,374	0
2.10	306,400	17,907	44,203	245,120	7,014	44,203	61,280	10,893	0
2.20	321,000	18,760	46,309	256,800	7,348	46,309	64,200	11,412	0
2.25	328,300	19,187	47,362	262,640	7,516	47,362	65,660	11,671	0

As with the SEAK AABM, the final step in deriving a TM estimate to associate with each AI in Table 1 involved converting the two categories of mortalities in NBC sport, LC and LIM, to the common currency of TCEs. Each quantity was multiplied by the ratio of the average AEQ in troll:average AEQ in sport for legal-sized fish (Table II.2.13). With this final conversion accomplished, all three categories of troll mortalities and the two categories of sport mortalities could be summed to a single total (Table II.2.14).

Table II.2.13. Scalars for converting NBC gear-specific LCEs to TCEs for the 1985-1995 base period.

Gear Sector	TCE Scalar
Troll	1.000
Sport	0.979

Table II.2.14. Panel C for development of the proposed Table 1 with TM limits for NBC, expressed in TCEs at selected AIs.

		Total TM	Totals in TCEs			Troll			Sport TCEs		
AI	LC	in TCEs	LC_g/t	LIM_g/t	SIM_g/t	LC_t	LIM_t	SIM_t	LC_s/t	LIM_s/t	SIM_s/t
0.30	39,000	46,714	38,838	2,250	5,626	31,200	893	5,626	7,638	1,358	0
0.40	52,000	62,286	51,784	3,001	7,502	41,600	1,190	7,502	10,184	1,810	0
0.495	64,400	77,139	64,132	3,716	9,291	51,520	1,474	9,291	12,612	2,242	0
0.50	65,000	77,857	64,730	3,751	9,377	52,000	1,488	9,377	12,730	2,263	0
0.60	78,000	93,429	77,675	4,501	11,253	62,400	1,786	11,253	15,275	2,715	0
0.70	91,000	109,000	90,621	5,251	13,128	72,800	2,083	13,128	17,821	3,168	0
0.80	104,000	124,572	103,567	6,001	15,003	83,200	2,381	15,003	20,367	3,620	0
0.90	117,000	140,143	116,513	6,751	16,879	93,600	2,678	16,879	22,913	4,073	0
1.00	130,000	155,715	129,459	7,501	18,754	104,000	2,976	18,754	25,459	4,525	0
1.005	130,700	156,553	130,156	7,542	18,855	104,560	2,992	18,855	25,596	4,550	0
1.05	136,500	163,501	135,932	7,877	19,692	109,200	3,125	19,692	26,732	4,752	0
1.10	143,000	171,286	142,405	8,252	20,630	114,400	3,274	20,630	28,005	4,978	0
1.20	156,000	186,858	155,351	9,002	22,505	124,800	3,571	22,505	30,551	5,431	0
1.205	156,700	187,696	156,048	9,042	22,606	125,360	3,587	22,606	30,688	5,455	0
1.30	170,700	204,466	169,990	9,850	24,626	136,560	3,908	24,626	33,430	5,942	0
1.40	185,300	221,954	184,529	10,693	26,732	148,240	4,242	26,732	36,289	6,451	0
1.50	200,000	239,561	199,168	11,541	28,853	160,000	4,578	28,853	39,168	6,962	0
1.505	219,600	263,038	218,686	12,672	31,680	175,680	5,027	31,680	43,006	7,645	0
1.60	233,400	279,568	232,429	13,468	33,671	186,720	5,343	33,671	45,709	8,125	0
1.70	248,000	297,056	246,968	14,311	35,778	198,400	5,677	35,778	48,568	8,633	0
1.80	262,600	314,544	261,507	15,153	37,884	210,080	6,012	37,884	51,427	9,141	0
1.90	277,200	332,032	276,046	15,996	39,990	221,760	6,346	39,990	54,286	9,650	0
2.00	291,800	349,520	290,586	16,838	42,096	233,440	6,680	42,096	57,146	10,158	0
2.10	306,400	367,008	305,125	17,680	44,203	245,120	7,014	44,203	60,005	10,666	0
2.20	321,000	384,496	319,664	18,523	46,309	256,800	7,348	46,309	62,864	11,174	0
2.25	328,300	393,240	326,934	18,944	47,362	262,640	7,516	47,362	64,294	11,429	0

II.2.D WCVI AABM Fishery

The same approach was used for the WCVI AABM fishery to derive an estimate of TM at each AI for a TM version of Table 1 as described for both the SEAK and NBC AABM fisheries. TM for each of the two gear sectors, troll and sport, was derived based on the allocation of 80% troll and 20% sport assumed in Table 1 of the 2008 Agreement (Table II.2.16). Tables of scalars and mortalities for each gear sector are presented in the same sequence in this section as in the preceding two sections with the final table of the section (Table II.2.21) showing the overall aggregate total mortality at selected AIs for the WCVI AABM fishery. Given that the derivation of TM in Table II.2.21 follows the same procedure as described for the other two AABMs, no further description is given here.

Table II.2.15. Average ratios of LIM:LC and SIM:LC for WCVI troll and sport for the 1985-1995 base period, extracted from Table II.1.28 and Table II.1.32.

Ratio Statistic	Gear Sector	
	Troll	Sport
LIM:LC	0.026	0.145
SIM:LC	0.361	0.046

Table II.2.16. Panel A for developing the proposed Table 1 with TM limits for WCVI, expressed in nominal numbers of fish. Allocation of fish at selected AIs amongst all gear sectors (g) as per the underlying relationship in Table 1 of the 2008 Agreement, which is 80% troll (t) and 20% sport (s), multiplied by the gear- and size-specific ratios in Table II.2.15. (The values in Table II.2.15 have been rounded to three digits; unrounded values were used to compute the LIM and SIM values below.)

AI	Nominal Totals			Troll			Sport		
	LC_g	LIM_g	SIM_g	LC_t	LIM_t	SIM_t	LC_s	LIM_s	SIM_s
0.30	38,500	1,927	11,484	30,800	814	11,129	7,700	1,113	355
0.40	51,300	2,568	15,302	41,040	1,084	14,829	10,260	1,484	473
0.495	63,500	3,178	18,941	50,800	1,342	18,356	12,700	1,836	585
0.50	74,900	3,749	22,341	59,920	1,583	21,651	14,980	2,166	690
0.60	89,800	4,495	26,786	71,840	1,898	25,958	17,960	2,597	827
0.70	104,800	5,246	31,260	83,840	2,215	30,294	20,960	3,031	966
0.80	119,800	5,996	35,734	95,840	2,532	34,630	23,960	3,465	1,104
0.90	134,800	6,747	40,208	107,840	2,849	38,966	26,960	3,898	1,242
1.00	149,700	7,493	44,653	119,760	3,164	43,273	29,940	4,329	1,379
1.005	172,000	8,609	51,304	137,600	3,635	49,719	34,400	4,974	1,585
1.05	179,700	8,995	53,601	143,760	3,798	51,945	35,940	5,197	1,656
1.10	188,200	9,420	56,136	150,560	3,978	54,402	37,640	5,443	1,734
1.20	205,400	10,281	61,267	164,320	4,341	59,374	41,080	5,940	1,893
1.205	206,200	10,321	61,505	164,960	4,358	59,605	41,240	5,963	1,900
1.30	222,500	11,137	66,367	178,000	4,703	64,317	44,500	6,434	2,050
1.40	239,600	11,993	71,468	191,680	5,064	69,260	47,920	6,929	2,208
1.50	256,700	12,849	76,569	205,360	5,425	74,203	51,340	7,424	2,365
1.505	257,600	12,894	76,837	206,080	5,444	74,463	51,520	7,450	2,374
1.60	273,800	13,705	81,669	219,040	5,787	79,146	54,760	7,918	2,523
1.70	290,900	14,561	86,770	232,720	6,148	84,089	58,180	8,413	2,680
1.80	308,000	15,417	91,870	246,400	6,510	89,032	61,600	8,907	2,838
1.90	325,100	16,273	96,971	260,080	6,871	93,975	65,020	9,402	2,996
2.00	342,300	17,133	102,101	273,840	7,234	98,947	68,460	9,899	3,154
2.10	359,40[illegible]	17,989	107,202	287,520	7,596	103,890	71,880	10,394	3,312
2.20	376,5[illegible]	18,845	112,303	301,200	7,957	108,833	75,300	10,888	3,469
2.25	385,000	19,271	114,838	308,000	8,137	111,290	77,000	11,134	3,548

Table II.2.17. AEQs for legal and sublegal sized Chinook in WCVI from PSC Chinook Model calibration 0907 for troll (T) and sport (S) sectors, 1985-1995.

Year	Average AEQs of legal-sized fish		Average AEQs of sublegal-sized fish	
	WCVI T	WCVI S	WCVI T	WCVI S
1985	0.884	0.881	0.666	0.596
1986	0.896	0.892	0.647	0.591
1987	0.892	0.882	0.718	0.581
1988	0.923	0.912	0.688	0.589
1989	0.893	0.881	0.710	0.590
1990	0.922	0.915	0.695	0.591
1991	0.897	0.885	0.698	0.592
1992	0.903	0.900	0.694	0.584
1993	0.902	0.890	0.734	0.590
1994	0.928	0.913	0.698	0.594
1995	0.909	0.895	0.693	0.596
Mean	0.904	0.895	0.695	0.590
SD	0.014	0.013	0.023	0.005
CV	1.6%	1.5%	3.4%	0.8%

Table II.2.18. Chinook in WCVI troll and sport for 1985-1995 and the ratio of average sublegal AEQ to average legal AEQ (i.e., the LCE scalar).

AEQ Statistic	Troll	Sport
$AEQ_{f,L}$	0.904	0.895
$AEQ_{f,SL}$	0.695	0.590
LCE_f	0.768	0.659

Table II.2.19. Panel B for developing the proposed Table 1 with TM limits for WCVI, expressed in gear-specific LCEs at selected AIs.

	Totals in Gear LCEs			Troll LCEs			Sport LCEs		
AI	LC_g	LIM_g	SIM_g	LC_t	LIM_t	SIM_t	LC_s	LIM_s	SIM_s
0.30	38,500	1,927	8,781	30,800	814	8,547	7,700	1,113	234
0.40	51,300	2,568	11,700	41,040	1,084	11,389	10,260	1,484	312
0.495	63,500	3,178	14,483	50,800	1,342	14,097	12,700	1,836	386
0.50	74,900	3,749	17,083	59,920	1,583	16,628	14,980	2,166	455
0.60	89,800	4,495	20,482	71,840	1,898	19,936	17,960	2,597	546
0.70	104,800	5,246	23,903	83,840	2,215	23,266	20,960	3,031	637
0.80	119,800	5,996	27,324	95,840	2,532	26,596	23,960	3,465	728
0.90	134,800	6,747	30,745	107,840	2,849	29,926	26,960	3,898	819
1.00	149,700	7,493	34,144	119,760	3,164	33,234	29,940	4,329	910
1.005	172,000	8,609	39,230	137,600	3,635	38,185	34,400	4,974	1,045
1.05	179,700	8,995	40,986	143,760	3,798	39,894	35,940	5,197	1,092
1.10	188,200	9,420	42,925	150,560	3,978	41,781	37,640	5,443	1,144
1.20	205,400	10,281	46,848	164,320	4,341	45,599	41,080	5,940	1,248
1.205	206,200	10,321	47,030	164,960	4,358	45,777	41,240	5,963	1,253
1.30	222,500	11,137	50,748	178,000	4,703	49,396	44,500	6,434	1,352
1.40	239,600	11,993	54,648	191,680	5,064	53,192	47,920	6,929	1,456
1.50	256,700	12,849	58,548	205,360	5,425	56,988	51,340	7,424	1,560
1.505	257,600	12,894	58,753	206,080	5,444	57,188	51,520	7,450	1,565
1.60	273,800	13,705	62,448	219,040	5,787	60,784	54,760	7,918	1,664
1.70	290,900	14,561	66,348	232,720	6,148	64,581	58,180	8,413	1,768
1.80	308,000	15,417	70,249	246,400	6,510	68,377	61,600	8,907	1,872
1.90	325,100	16,273	74,149	260,080	6,871	72,173	65,020	9,402	1,975
2.00	342,300	17,133	78,072	273,840	7,234	75,992	68,460	9,899	2,080
2.10	359,400	17,989	81,972	287,520	7,596	79,788	71,880	10,394	2,184
2.20	376,500	18,845	85,872	301,200	7,957	83,584	75,300	10,888	2,288
2.25	385,000	19,271	87,811	308,000	8,137	85,471	77,000	11,134	2,339

Table II.2.20. Scalars for converting WCVI gear-specific LCEs to TCEs for the 1985-1995 base period.

Gear Sector	TCE Scalar
Troll	1.000
Sport	0.990

Table II.2.21. Panel C for development of the proposed Table 1 with TM limits for WCVI, expressed in TCEs at selected AIs.

		Total TM	Totals in TCEs			Troll			Sport TCEs		
AI	LC	in TCEs	LC_g/t	LIM_g/t	SIM_g/t	LC_t	LIM_t	SIM_t	LC_s/t	LIM_s/t	SIM_s/t
0.30	38,500	49,115	38,420	1,916	8,779	30,800	814	8,547	7,620	1,102	232
0.40	51,300	65,444	51,194	2,552	11,697	41,040	1,084	11,389	10,154	1,468	309
0.495	63,500	81,007	63,369	3,159	14,479	50,800	1,342	14,097	12,569	1,817	382
0.50	74,900	95,550	74,745	3,727	17,078	59,920	1,583	16,628	14,825	2,144	450
0.60	89,800	114,558	89,614	4,468	20,476	71,840	1,898	19,936	17,774	2,570	540
0.70	104,800	133,694	104,583	5,214	23,896	83,840	2,215	23,266	20,743	2,999	630
0.80	119,800	152,829	119,552	5,961	27,316	95,840	2,532	26,596	23,712	3,429	720
0.90	134,800	171,965	134,521	6,707	30,737	107,840	2,849	29,926	26,681	3,858	811
1.00	149,700	190,973	149,390	7,448	34,134	119,760	3,164	33,234	29,630	4,284	900
1.005	172,000	219,421	171,644	8,558	39,219	137,600	3,635	38,185	34,044	4,923	1,034
1.05	179,700	229,244	179,328	8,941	40,975	143,760	3,798	39,894	35,568	5,143	1,081
1.10	188,200	240,087	187,811	9,364	42,913	150,560	3,978	41,781	37,251	5,386	1,132
1.20	205,400	262,029	204,975	10,220	46,835	164,320	4,341	45,599	40,655	5,879	1,235
1.205	206,200	263,050	205,773	10,259	47,017	164,960	4,358	45,777	40,813	5,901	1,240
1.30	222,500	283,844	222,040	11,070	50,734	178,000	4,703	49,396	44,040	6,368	1,338
1.40	239,600	305,658	239,104	11,921	54,633	191,680	5,064	53,192	47,424	6,857	1,441
1.50	256,700	327,473	256,169	12,772	58,532	205,360	5,425	56,988	50,809	7,347	1,544
1.505	257,600	328,621	257,067	12,817	58,737	206,080	5,444	57,188	50,987	7,372	1,549
1.60	273,800	349,287	273,233	13,623	62,431	219,040	5,787	60,784	54,193	7,836	1,647
1.70	290,900	371,102	290,298	14,474	66,330	232,720	6,148	64,581	57,578	8,326	1,749
1.80	308,000	392,916	307,363	15,324	70,229	246,400	6,510	68,377	60,963	8,815	1,852
1.90	325,100	414,731	324,427	16,175	74,128	260,080	6,871	72,173	64,347	9,304	1,955
2.00	342,300	436,673	341,592	17,031	78,050	273,840	7,234	75,992	67,752	9,797	2,058
2.10	359,400	458,488	358,656	17,882	81,949	287,520	7,596	79,788	71,136	10,286	2,161
2.20	376,500	480,302	375,721	18,733	85,848	301,200	7,957	83,584	74,521	10,775	2,264
2.25	385,000	491,146	384,203	19,156	87,787	308,000	8,137	85,471	76,203	11,019	2,315

II.2.E Table 1 TM Limits and Associated IM and LCE Scalars for the AABM Fisheries

The sections above describe the computation of potential TM limits for each of the AABM fisheries. In this section, the TM limits are compiled for all three AABM fisheries in a summary table analogous to Table 1 in the 2008 Agreement. The IM ratios and AEQ scalars used to develop TM limits for each fishery are also summarized for all AABM fisheries for comparative purposes.

Table 1 in the 2008 Agreement prescribes LC limits (total for all gear types) for each AABM fishery at each level of the AI. To generate a summary TM Table 1, the TM limits (summed across all gear types) in the Panel C tables for each AABM fishery (Table II.2.7, Table II.2.14, Table II.2.21) are compiled for the AI range in Table II.2.22. The associated LC limits in the current Table 1 are also listed for reference. However, the LC and TM numbers are not directly comparable, because: 1) TM limits include the IM component of mortality and 2) TM limits are expressed in TCEs, while LC limits are in nominal numbers of fish landed.

Table II.2.22. LC specified in nominal fish for AABM fisheries at ascending levels of the AIs, and potential TM limits expressed in TCEs.

AI	SEAK		NBC		WCVI	
	LC	TM	LC	TM	LC	TM
0.25	44,600	68,453	32,500	38,929	32,100	40,950
0.30	50,200	75,490	39,000	46,714	38,500	49,115
0.35	55,700	82,402	45,500	54,500	44,900	57,279
0.40	61,200	89,314	52,000	62,286	51,300	65,444
0.45	66,700	96,225	58,500	70,072	57,800	73,736
0.495	71,700	102,509	64,400	77,139	63,500	81,007
0.50	72,300	103,263	65,000	77,857	74,900	95,550
0.55	77,800	110,175	71,500	85,643	82,400	105,118
0.60	83,300	117,086	78,000	93,429	89,800	114,558
0.65	88,800	123,998	84,500	101,215	97,300	124,126
0.70	94,400	131,036	91,000	109,000	104,800	133,694
0.75	99,900	137,948	97,500	116,786	112,300	143,261
0.80	105,400	144,859	104,000	124,572	119,800	152,829
0.85	110,900	151,771	110,500	132,358	127,300	162,397
0.90	116,500	158,809	117,000	140,143	134,800	171,965
0.95	122,000	165,720	123,500	147,929	142,300	181,532
1.00	127,500	172,632	130,000	155,715	149,700	190,973
1.005	128,700	174,140	130,700	156,553	172,000	219,421
1.05	139,600	187,838	136,500	163,501	179,700	229,244
1.10	151,700	203,044	143,000	171,286	188,200	240,087
1.15	163,800	218,250	149,500	179,072	196,800	251,058
1.20	176,000	233,582	156,000	186,858	205,400	262,029
1.205	199,800	263,491	156,700	187,696	206,200	263,050
1.25	206,700	272,162	163,300	195,602	213,900	272,873
1.30	214,200	281,587	170,700	204,466	222,500	283,844
1.35	221,800	291,138	178,000	213,210	231,000	294,687
1.40	229,400	300,689	185,300	221,954	239,600	305,658
1.45	237,000	310,240	192,700	230,817	248,100	316,502
1.50	244,600	319,791	200,000	239,561	256,700	327,473
1.505	264,400	344,673	219,600	263,038	257,600	328,621
1.55	271,800	353,973	226,100	270,824	265,300	338,444
1.60	280,000	364,278	233,400	279,568	273,800	349,287
1.65	288,200	374,583	240,700	288,312	282,400	360,258
1.70	296,400	384,887	248,000	297,056	290,900	371,102
1.75	304,600	395,192	255,300	305,800	299,500	382,073
1.80	312,900	405,623	262,600	314,544	308,000	392,916
1.85	321,100	415,928	269,900	323,288	316,600	403,887
1.90	329,300	426,233	277,200	332,032	325,100	414,731
1.95	337,500	436,537	284,500	340,776	333,700	425,702
2.00	345,700	446,842	291,800	349,520	342,300	436,673
2.05	353,900	457,147	299,100	358,264	350,800	447,517
2.10	362,200	467,578	306,400	367,008	359,400	458,488
2.15	370,400	477,883	313,700	375,752	367,900	469,331
2.20	378,600	488,187	321,000	384,496	376,500	480,302
2.25	386,800	498,492	328,300	393,240	385,000	491,146

The average IM:LC ratios estimated for the 1985-1995 base period were used to project expected IM at the LC limits for each AI in Table 1. These IM:LC ratios are listed by gear type for each

AABM fishery in Table II.2.1, Table II.2.8, and Table II.2.15. They are compiled for all three AABM fisheries in Table II.2.23 for ease of direct comparison between fisheries.

Table II.2.23. Average ratios of LIM:LC and SIM:LC estimated for the 1985-1995 base period, by gear sector for each AABM fishery.

Fishery	Ratio Statistic	Gear Sector		
		Troll	Sport	Net
SEAK	LIM:LC	0.102	0.093	0.274
SEAK	SIM:LC	0.237	0.169	1.171
NBC	LIM:LC	0.029	0.178	NA
NBC	SIM:LC	0.235	0.000	NA
WCVI	LIM:LC	0.026	0.145	NA
WCVI	SIM:LC	0.361	0.046	NA

Average AEQs for the 1985-1995 base period were used to develop LCEs between legal- and sublegal-sized fish within each gear sector. These average AEQs are listed by gear sector for each AABM fishery in Table II.2.4, Table II.2.11, and Table II.2.18. They are compiled for all three AABM fisheries in Table II.2.24 for ease of direct comparison between fisheries.

Table II.2.24. Average AEQs for legal- and sublegal-sized fish in AABM fisheries for 1985-1995, and the LCE_f (= ratio of average AEQ_{SL} to average AEQ_L).

AEQ Statistic	AABM Fishery	Troll	Sport	Net
$AEQ_{f,L}$	SEAK	0.928	0.899	0.844
$AEQ_{f,SL}$	SEAK	0.684	0.657	0.657
LCE_f	SEAK	0.736	0.731	0.779
$AEQ_{f,L}$	NBC	0.891	0.872	NA
$AEQ_{f,SL}$	NBC	0.685	0.620	NA
LCE_f	NBC	0.769	0.711	NA
$AEQ_{f,L}$	WCVI	0.904	0.895	NA
$AEQ_{f,SL}$	WCVI	0.695	0.590	NA
LCE_f	WCVI	0.768	0.659	NA

The base period average $AEQ_{f,L}$ to base period average $AEQ_{f(t),L}$ for the troll gear sector was used to calculate scalars for converting to TCEs based on equation II.2.7. These scalars were then used to convert within-gear LCEs to TCEs. The TCE conversion scalars are shown by AABM fishery in Table II.2.12, and Table II.2.19. They are compiled for all three AABM fisheries in Table II.2.25 for ease of direct comparison between fisheries.

Table II.2.25. Scalars for converting sport and net gear-specific LCEs to TCEs for the 1985-1995 base period.

Sector	SEAK TCEs	NBC TCEs	WCVI TCEs
Troll	1.00	1.00	1.00
Sport	0.97	0.98	0.99
Net	0.91	NA	NA

III DESCRIPTION OF PRE- AND POST-SEASON MANAGEMENT APPLICATION TO AABM FISHERIES

III.1 CTC REPORTING REQUIREMENTS AND CURRENT REPORTS

The 2008 Agreement assigns the CTC specific responsibilities in Annex IV, Chapter 3, paragraph 2(b). These responsibilities include the following:

(i) *evaluate management actions for their consistency with measures set out in this Chapter;*

(ii) *report annually on catches, harvest rate indices, estimates of incidental mortality and exploitation rates for all Chinook fisheries and stocks harvested within the Treaty area.*

The CTC publishes an annual report on catch and escapement, which includes detailed reporting of LC for Chinook salmon caught in PSC fisheries. These reports have included available IM data for the PSC fisheries since the 2003 report (CTC 2004b). The CTC also publishes an annual report on the exploitation rate analysis and model calibration to evaluate PSC Chinook fisheries in relation to management objectives. These reports include a comparison of the LC against the allowable LCs associated with both preseason and post-season estimates of the AI for each AABM fishery (e.g., Table 3.4, CTC 2008). An annual overage or underage of LC is calculated for each AABM fishery relative to the allowable LC for the fishery associated with the post-season AI, and a cumulative overage or underage is computed for the duration of the Agreement (e.g., Table 3.5, CTC 2008).

III.2 REPORTING UNDER A TM REGIME

The 2008 Agreement also requires the CTC in Annex IV, Chapter 3, paragraph 7 to complete the following tasks:

(g) that, once total mortality management is implemented, the CTC shall complete an annual post-season assessment which includes:

- *(i) a periodic evaluation of estimates of encounters and incidental mortalities in all fisheries, against standards developed by the CTC;*
- *(ii) a comparison of post-season estimates of landed catch equivalent fishing mortality against allowable landed catch equivalent fishing mortality as estimated with the post-season abundance index;*
- *(iii)a report of post-season estimates of total mortality; and*
- (iv)*a description of the causes (if identifiable) of significant deviations from expected total mortalities*

Under a TM regime for AABM fisheries, the CTC will continue to report LC and comprehensive estimates of IM for each gear type within the fishery in the catch and escapement report. The CTC will also continue to report the post-season AI for the prior catch year in the exploitation rate and model calibration report. The estimates of both LC and IM will then be translated into the

appropriate TCEs as the measure of TM, using the methods developed in Section II.2 for each specific AABM fishery and gear type.

The TCEs for each gear type and the sum of TCEs for each AABM fishery will be compared with the allowable TM associated with both preseason and post-season estimates of the AI from the revised TM Table 1. The CTC will also compare the LC for each AABM fishery with the LC targets from the original LC Table 1 from the 2008 Agreement. A comparison of observed TCEs against allowable TCEs associated with the post-season AI will be published for each AABM fishery for the duration of the Agreement.

Although the 2008 Agreement directs the parties to manage to a LC or TM limit for the AABM fisheries aggregated across gear sectors (Annex IV, Chapter 3, paragraph 10(b),(c),(d)), the new Agreement also states that *"transfers of Chinook salmon mortalities between gears, with the exception of net fisheries, and between landed catch and incidental mortality are allowed and will be made in terms of landed catch equivalents"* (Annex IV, Chapter 3, paragraph 10(b)). The SEAK AABM fishery is the only AABM fishery that includes a net component (purse seine and gillnet combined). The formulas defining the relationship of LC to AI use a fixed LC of 17,000 for the SEAK net fishery at each AI (Annex IV, Chapter 3, Appendix B). However, the current Alaska Board of Fish (BOF) allocation strategy allocates 7.2% of the allowable all-gear treaty catch in the SEAK fishery for purse seine and drift gillnet harvest (4.3% for purse seine and 2.9% for drift gillnet) and 1,000 fish for setnet harvest. The SEAK net fisheries do not have directed harvest of treaty Chinook salmon outside of terminal areas, but take them as incidental catch during the directed harvest of pink, chum, coho, and sockeye salmon.

The BOF rationale for allocating a percentage of the LC or TM limit for SEAK net fisheries rather than a fixed number is that incidental catch in the purse seine and gill net fisheries are expected to be higher when abundance is higher. By accounting for the expected changes in incidental catch, managers can effectively constrain the troll and sport components to reduce the probability of exceeding the LC or TM limits for the AABM fishery as a whole. Consensus within the CTC has not been reached as to whether this is a valid way of accounting for variability in non-targeted net catch in relation to abundance, or a proscribed transfer of mortality to and from the net component of the SEAK fishery. Therefore, pending clarification from the PSC Commissioners, the CTC would publish the overage and underage of the SEAK net TCEs in relation to both the TCEs associated with the 17,000 LC specified in Appendix B (2008 Agreement) and the TCEs associated with the BOF management targets.

Current monitoring and estimation programs may be biased in their annual estimates of IM under a TM management regime because of the possible incentive to underreport encounters of released fish. The CTC will need to review monitoring programs and determine that the observed estimates of IM are unbiased or corrected for bias (Section III.8.B). Estimates from monitoring programs that meet validation criteria would be used in annual CTC assessments of TM. The CTC would also estimate the IM based on the empirical relationships derived from appropriate data collected prior to TM management (Section III.4) to compare with annual estimates from monitoring programs.

The 2008 Agreement mandates the use of the average historical relationship between LC and IM for 1985-1995 for the computation of Table 1. The TMWG also used average relationships between LC and IM from 1999-2008 in its analysis of the potential effects of implementation of TM management in Section IV of this report. The average may not be the best estimator of IM as it

does not account for interannual variation in the IM:LC ratios. Estimators using historical relationships between TIM or TIM:LC and factors such as LC and AI may provide better estimates of IM than the average. In Section III.6 of this report, the TMWG examined some potential approaches to improving the annual estimate of TIM and TM.

The CTC also used average AEQ values to develop the scalars for LCEs for the IM base period (1985-1995) for the development of Table 1 and for 1999-2008 period for the analysis of the potential effects of implementation of TM management in Section IV of this report. The AEQ values of sublegal and legal fish within each gear sector can also vary annually, and thus affect the estimation of LCEs and TM. In Section III.7, the CTC looked at the variation in AEQs and examined the effect on scalars used to estimate LCEs.

III.3 PRESEASON PROJECTION OF TM LIMITS

III.3.A Current Projection of LC Limits

The CTC currently performs an annual preseason calibration of the PSC Chinook model to provide a forecast of AIs for the upcoming fishing year. These AIs are used to set management targets in LC for the AABM fisheries for the upcoming fishing season, as per the 2008 Agreement Table 1. The Parties then determine management targets for the gear types for each AABM fishery under their jurisdictions based on their internal allocation strategies (Figure III.5.1). LC is currently apportioned on a 1:1 basis between gear types (e.g. a troll LC is equal to a sport LC). The results of the preseason calibration and the target LC for each AABM fishery are subsequently published in the CTC annual report on exploitation rate analysis and model calibration (e.g., CTC 2008).

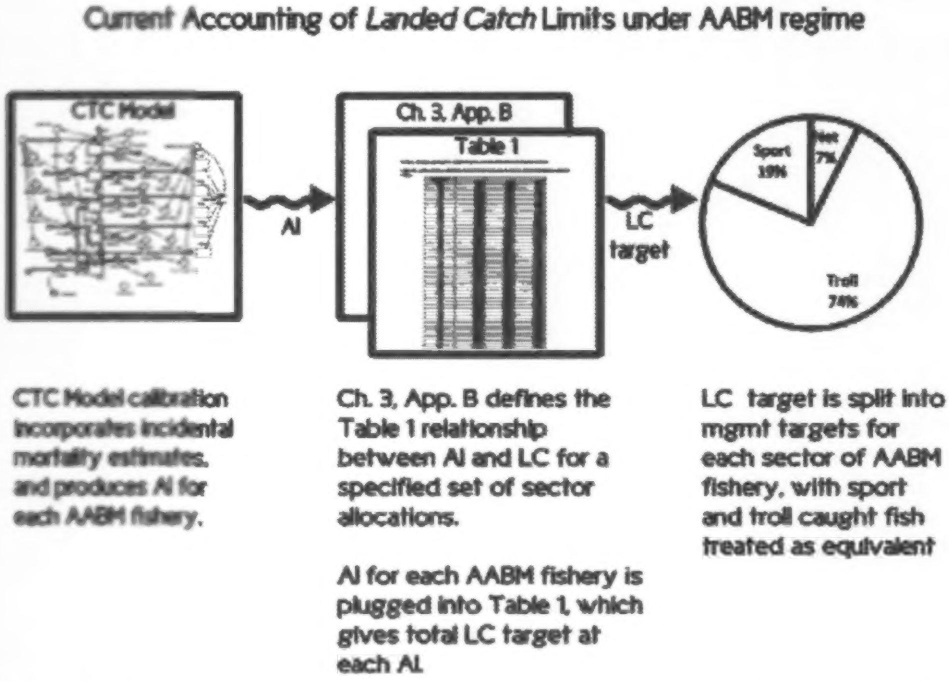

Figure III.3.1. Schematic of the accounting procedure required for LC under LC fishing regime.

III.3.B Projection of TM Limits

Under the TM regime, the preseason calibration would again be used to forecast AIs for each AABM fishery, but the management targets in relation to the AIs would be in TCEs from the revised TM Table 1 (Figure III.5.2). Allocation of the TCEs to define management targets for component gear types of an AABM would depend on the allocation strategy of the Party responsible for the fishery. Management targets within AABM fisheries are typically based on allocations in terms of LC. The LC allocations among gear types would need to be translated into TCEs, based on the expected IM:LC ratios for the gear types and the LCE method applied.

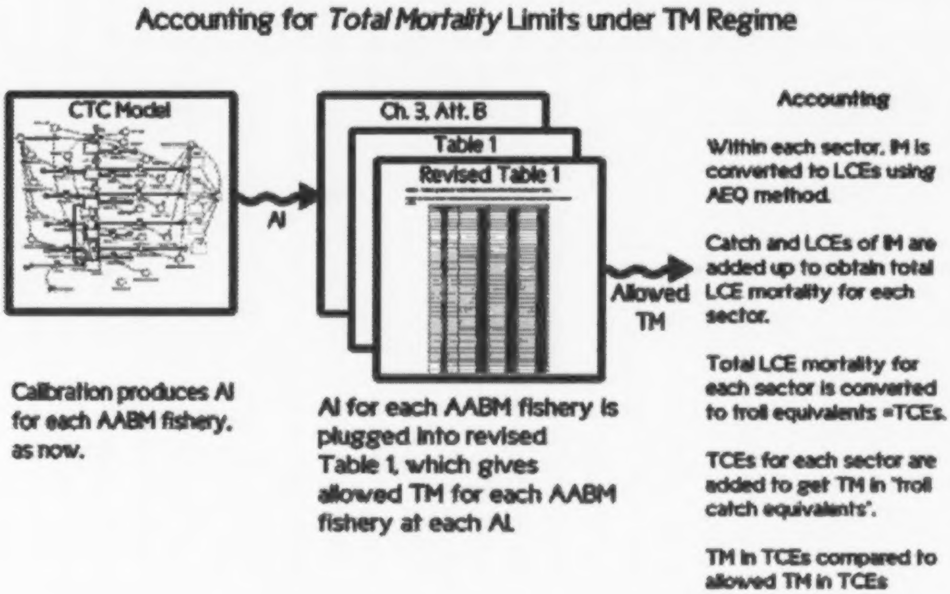

Figure III.3.2. Schematic of the accounting procedure required for TM under TM fishing regime.

Table 1 in the 2008 Agreement is based on the relationship of LC and AI specified in Annex IV, Chapter 3, Appendix B for each of the AABM fisheries. However, the current management allocations may differ substantially from the relationships specified in Appendix B, and will affect the realized management targets for each gear type within an AABM fishery; Section IV.1 below provides an analysis of these effects.

To set preseason targets for the SEAK fishery under current BOF allocation policy, the TM limits for the preseason AI from Table 1 must be translated into LC and IM components based initially on TCEs. The initial estimate of LC is then allocated to the net fishery, and translated back into TCEs based on the appropriate TIM estimates. The allowable net catch, in TCEs, is then subtracted from the all-gear TM limit, and the remaining TCEs for the TM limit are allocated among the troll and recreational sectors, using an iterative fit algorithm, so that the TM limit is equaled while the

projected LC for troll and sport combined is 80% troll, 20% sport in LC. It will be necessary to iteratively adjust the initial estimate of the LC in the net fishery to attain the exact BOF allocations in terms of LC.

To set preseason targets for the NBC and WCVI fisheries, CDFO will need to determine preseason estimates of the allocation of LC for the sport and troll sectors, either in terms of proportional allocation or fixed targets for specific gear sectors. When not curtailed for other conservation concerns, sport fisheries are given precedent in the directed harvest of Chinook salmon in the Canadian AABM fisheries, with the sport fishery harvesting to its capacity and the troll fishery constrained to the remainder of the allowable LC. In the NBC fishery, sport harvest averaged 8% of the fishery from 1985 to 1995. Since then, recreational harvest has taken a much larger percentage of the allowable catch, averaging 27% of the LC allocation based on the AIs for 1999-2008. Similarly, sport harvest has taken an increasingly higher percentage of the catch in the WCVI fishery. The WCVI sport fishery averaged 6% of the AABM LC allocation for 1992-1995, and 27% for 1999-2008 (CTC 2009a). In addition, the 30% reduction in the WCVI allowable catch mandated by the 2008 Agreement is expected to be taken primarily from the commercial troll sector, skewing the harvest allocation in WCVI further to the sport sector. The TM limit in TCEs would be allocated between the gear sectors using an iterative fit algorithm so that the TM limit is equaled and the projected LC for troll and sport combined is apportioned as per the preseason proportional or numerical allocation of LC.

III.4 ESTIMATION OF 1999-2008 IM RATIOS FOR IMPLEMENTATION ANALYSIS

III.4.A SEAK AABM IM Estimates and 1999-2008 IM Ratios

The following methods were used to estimate the numbers of sublegal- and legal-sized Chinook encounters in the SEAK troll, sport, and net CNR and CR fisheries during 1999-2008. Incidental mortalities were calculated from these encounters, and the 1999-2008 average ratio of IM to LC was computed for sublegal- and legal-sized Chinook.

III.4.A.1 SEAK Troll Fishery

Legal- and sublegal-sized encounters from the summer CNR and CR fisheries were estimated from direct observational data for 1999-2006 (described in Section II.1.A and in Bloomquist et al. 1999, Bloomquist and Carlile 2001, 2002). Chinook salmon encountered in 2007 and 2008 were estimated from one of a series of linear regressions developed from the relationship between summer troll effort and summer encounter estimates from years with direct observational years. Sublegal-sized Chinook encountered in the CR period in 2007 and 2008 were estimated using regression model 1 (Appendix A, Table A1). Legal-sized Chinook encountered in the CNR period in 2007 and 2008 were estimated using regression model 2 (Appendix A, Table A1). Sublegal-sized Chinook salmon encountered in the CNR period in 2007 and 2008 were estimated using regression model 7 (Appendix A, Table A1). Sublegal-sized Chinook encountered in the winter and spring troll fisheries (Appendix B in this report) were estimated as described in Section II.1.A.

Encounters were multiplied by their respective IM rates (Table III.4.1) to estimate incidental mortalities in the SEAK troll fishery (Table III.4.2). Legal-sized drop-off mortalities during CR periods were estimated by multiplying the drop-off mortality rate by the SEAK troll LC. Legal-

sized Chinook drop-off mortalities were added to legal-sized CNR mortalities to estimate total LIMs while sublegal-sized CNR mortalities were added to shakers to obtain an estimate of total SIMs (Table III.4.2).

Table III.4.1. Total LC, legal- and sublegal-sized Chinook encounters, and IM rates for the SEAK troll fishery, 1999-2008.

		Summer CNR		All CR
Year	LC	Legal	Sublegal	Sublegal
1999	146,219	72,747	43,512	18,918
2000	158,717	42,070	27,379	55,230
2001	153,280	47,677	37,386	67,925
2002	325,308	28,242	52,078	82,313
2003	330,692	38,538	18,093	63,658
2004	354,658	54,359	26,555	36,631
2005	338,446	45,045	19,862	37,746
2006	282,315	38,177	28,580	40,538
2007	268,149	41,053	27,188	62,297
2008	151,926	50,779	33,629	36,606
IM Rates	0.008[1]	0.219[2]	0.263[2]	0.263[2]

[1] Drop-off rate from CTC (1997).
[2] Drop-off rate + immediate mortality rate from CTC (1997).

Table III.4.2. Estimated Chinook salmon LIMs and SIMs in the SEAK troll fishery, 1999-2008.

Year	LIM Drop-off	LIM CNR	LIM Total	SIM CNR	SIM CR	SIM Total
1999	1,170	15,932	17,101	11,444	4,975	16,419
2000	1,270	9,213	10,483	7,201	14,526	21,726
2001	1,226	10,441	11,668	9,832	17,864	27,697
2002	2,602	6,185	8,787	13,697	21,648	35,345
2003	2,646	8,440	11,085	4,759	16,742	21,501
2004	2,837	11,905	14,742	6,984	9,634	16,618
2005	2,708	9,865	12,572	5,224	9,927	15,151
2006	2,259	8,361	10,619	7,517	10,661	18,178
2007	2,145	8,991	11,136	7,150	16,384	23,535
2008	1,215	11,121	12,336	8,844	9,627	18,472

Total LIMs were divided by LC to obtain a ratio for each year from 1999-2008 (Table III.4.3), and total SIMs were divided by LC to obtain a ratio for the same years (Table III.4.3). The averages of these ratios were then computed as (Table III.4.3):

$$\overline{R}_{LIM_{99-08}} = \frac{\sum_{y=1999}^{2008} \frac{LIM_y}{LC_y}}{10} \quad \text{(Equation III.4.1)}$$

$$\overline{R}_{SIM_{99-08}} = \frac{\sum_{y=1999}^{2008} \frac{SIM_y}{LC_y}}{10} \quad \text{(Equation III.4.2)}$$

where $\overline{R}_{LIM_{99-08}}$ = the average ratio of LIMs to LC from 1999-2008, $\overline{R}_{SIM_{99-08}}$ = the average ratio of SIMs to LC from 1999-2008, LIM_y = the number of LIMs in year y, SIM_y = the number of SIMs in year y, and LC_y = the LC in year y.

Table III.4.3. Ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for SEAK troll fishery, 1999-2008.

Year	LIM:LC	SIM:LC
1999	0.117	0.112
2000	0.066	0.137
2001	0.076	0.181
2002	0.027	0.109
2003	0.034	0.065
2004	0.042	0.047
2005	0.037	0.045
2006	0.038	0.064
2007	0.042	0.088
2008	0.081	0.122
$\overline{R}_{LIM_{99-08}}$	0.056	-
$\overline{R}_{SIM_{99-08}}$	-	0.097

III.4.A.2 SEAK Sport Fishery

Legal- and sublegal-sized Chinook released and corresponding Chinook incidental mortalities in the SEAK sport fishery from 1999-2008 were estimated from the annual SWHS. A standard survey was mailed to a sample of license holders and an additional supplementary survey was mailed to a different sample of license holders. A stratified random sample design was used with the following residential strata: Alaska residents, other U.S. residents, Canadian residents, and other foreign residents (Howe et al. 2001, Walker et al. 2003, Jennings et al. 2004, 2006a, 2006b, 2007, 2009a, 2009b, 2010a, 2010b). Chinook harvest (i.e., fish retained, synonymous with LC) and catch (i.e. fish retained plus fish released) were stratified into legal and sublegal size categories and into fishing sites based on the geographic location of the catch. Chinook harvest and catch at each fishing site for each year were estimated using equation II.1.6. Beginning in 2001, $\hat{R}_h$ in equation II.1.6 was changed to $\hat{R}_s$ with the s denoting one of two residential groups (Alaska residents or non-residents, Jennings et al. 2004).

Legal- and sublegal-sized Chinook released each year were calculated by subtracting the size-specific estimate of Chinook harvested from the size-specific estimate of Chinook caught. Releases were multiplied by their respective IM rates (Table III.4.4) to estimate LIMs and SIMs in the SEAK sport fishery (Table III.4.5). Legal-sized drop-off mortalities were estimated by multiplying the drop-off mortality rate by the total SEAK sport harvest. Legal-sized drop-off mortalities were added to legal-sized release mortalities to estimate total LIMs (Table III.4.5). The average ratios of LIMs to LC and SIMs to LC for the SEAK sport fishery from 1999-2008 were estimated using equations III.4.1 and III.4.2 (Table III.4.6).

Table III.4.4. Total LC, legal- and sublegal-sized Chinook releases, and IM rates for the SEAK sport fishery, 1999-2008.

Year	LC	Legal	Sublegal
1999	72,081	27,929	72,131
2000	63,173	25,073	50,403
2001	72,291	35,931	57,295
2002	69,537	36,019	54,709
2003	69,370	26,854	57,894
2004	80,572	43,148	63,991
2005	86,575	28,002	77,034
2006	85,794	25,437	63,362
2007	82,848	20,878	70,672
2008	49,265	27,984	43,577
IM Rates	0.036[1]	0.159[2]	0.159[2]

[1] Drop-off rate from CTC (1997).
[2] Drop-off rate + immediate mortality rate from CTC (1997).

Table III.4.5. Estimated Chinook salmon LIMs and SIMs in the SEAK sport fishery, 1999-2008.

Year	LIM Drop-off	LIM CR	LIM Total	SIM Total
1999	2,595	4,441	7,036	11,469
2000	2,274	3,987	6,261	8,014
2001	2,602	5,713	8,316	9,110
2002	2,503	5,727	8,230	8,699
2003	2,497	4,270	6,767	9,205
2004	2,901	6,861	9,761	10,175
2005	3,117	4,452	7,569	12,248
2006	3,089	4,044	7,133	10,075
2007	2,983	3,320	6,302	11,237
2008	1,774	4,449	6,223	6,929

Table III.4.6. Estimated ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for SEAK sport fishery, 1999-2008.

Year	LIM:LC	SIM:LC
1999	0.098	0.159
2000	0.099	0.127
2001	0.115	0.126
2002	0.118	0.125
2003	0.098	0.133
2004	0.121	0.126
2005	0.087	0.141
2006	0.083	0.117
2007	0.076	0.136
2008	0.126	0.141
$\overline{R}_{LIM_{99-08}}$	0.102	-
$\overline{R}_{SIM_{99-08}}$	-	0.133

III.4.A.3 SEAK Net Fishery

The same methods used to estimate encounters and IM in the SEAK net fishery for 1985-1995 in Section II.1.A.3 were also used for 1999-2008. Annual LC and encounters for the net fisheries, combining set and drift gillnet catches and trap net and purse seine catches, were compiled for 1999-2008 in Table III.4.7. There were no estimates of CNR encounters in the gillnet fisheries since all fish caught can be retained and sold. Thus the computation of IM in the gillnet fishery was limited to estimating LIM by applying the appropriate drop-off mortality rate to the LC (Table III.4.7). Sublegal encounters during seine CR periods and legal and sublegal encounters during seine CNR periods (Table III.4.7) were estimated using the CPL approach described in Section II.1.A.3. The encounter estimates and mortality rates in Table III.4.7 were used to estimate LIM and SIM for the net fishery (Table III.4.8). Cumulative annual estimates of LIM and SIM were divided by LC to calculate the IM:LC ratios for 1999-2008 (Table III.4.9).

Table III.4.7. Total LC, legal- and sublegal-sized Chinook encounters, and IM rates for the SEAK gillnet and seine fisheries, 1999-2008.

			Seine CNR Period		Seine CR Period
Year	Gillnet LC[3]	Seine LC[4]	Legal	Sublegal	Sublegal
1999	14,820	17,900	2,284	6,015	3,232
2000	18,495	22,905	934	2,460	1,074
2001	19,724	20,439	2,010	5,292	2,614
2002	13,994	17,695	593	1,562	3,490
2003	15,240	24,134	820	2,159	12,923
2004	24,405	39,633	12,689	1,408	5,526
2005	51,751	19,867	0	0	8,331
2006	45,415	24,969	0	0	10,065
2007	28,617	27,267	12,414	32,694	10,865
2008	30,609	15,540	379	999	461
IM Rates	0.02[1]		0.51[2]	0.735[2]	0.858[2]

[1] Gillnet drop-off rate from CTC (1997).
[2] Drop-off rate + immediate mortality rate from CTC (1997).
[3] Includes setnet catch.
[4] Includes trap catch.

Table III.4.8. Estimated Chinook salmon LIMs and SIMs in the SEAK net fishery, 1999-2008.

Year	LIM Drop-off	LIM CNR	LIM Total	SIM CNR	SIM CR	SIM Total
1999	296	1,165	1,461	4,421	2,773	7,194
2000	370	476	846	1,808	921	2,730
2001	394	1,025	1,419	3,890	2,243	6,133
2002	280	303	582	1,148	2,994	4,143
2003	305	418	723	1,587	11,088	12,674
2004	488	6,471	6,959	1,035	4,742	5,776
2005	1,035	0	1,035	0	7,148	7,148
2006	908	0	908	0	8,636	8,636
2007	572	6,331	6,904	24,030	9,322	33,352
2008	612	194	806	735	396	1,130

Table III.4.9. Estimated ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for SEAK net fishery, 1999-2008.

Year	LIM:LC	SIM:LC
1999	0.045	0.220
2000	0.020	0.066
2001	0.035	0.153
2002	0.018	0.131
2003	0.018	0.322
2004	0.109	0.090
2005	0.014	0.100
2006	0.013	0.123
2007	0.124	0.597
2008	0.017	0.024
$\overline{R}_{LIM_{99-08}}$	0.041	-
$\overline{R}_{SIM_{99-08}}$	-	0.183

III.4.B NBC AABM IM Estimates and 1999-2008 IM Ratios

III.4.B.1 NBC Troll Fishery

Logbooks and dockside monitoring programs are currently used to estimate Chinook LC and IM in NBC troll fisheries. Logbook data can be queried from the Fishery Operation System (FOS), maintained by the Fisheries Management Information Services of Fisheries and Oceans Canada, where encounters have been stratified for retention (CR) and non-retention (CNR) fisheries since 2001 and stratified by legal- and sublegal-sized since 2004. Since 2005, all Chinook LC has been counted by dockside monitors. Releases are unverified, since fisher-independent data sources (e.g. observers) were not available for the NBC troll fishery.

A consistent underreporting bias in the numbers of sublegal-sized Chinook salmon released in CR fisheries was evident in the WCVI troll fishery based on observer data from 1998-2008, and a correction factor (*CF*) of 1.67 was used to estimate sublegal mortalities (Vélez-Espino et al. 2010). Observer data were too sparse to develop separate *CF*s for WCVI troll CNR fisheries (Vélez-Espino et al. 2010). Given the absence of observer data for NBC, the WCVI *CF* was considered appropriate for the NBC CR and CNR fisheries until future studies provide more reliable information. It was acknowledged, however, that underreporting bias could change due to differences in minimum size limits, fishery management systems (e.g., ITQ), and fisheries dynamics between WCVI and NBC, likely translating into different encounter rates.

For years prior to 2004, sublegal-sized Chinook releases in CNR fisheries ($SL^{c}_{CNR,i}$) was computed as:

$$SL^{c}{}_{CNR,i} = CF\left(\frac{E_{CNR,i} * R_{CR,i}}{LC_i + R_{CR,i}}\right) \qquad \text{(Equation III.4.3)}$$

where CF is the underreporting correction factor (1.67), $E_{CNR,i}$ is the total encounters (legal and sublegal) in CNR fisheries in year i, $R_{CR,i}$ is the uncorrected Chinook releases in CR fisheries, and LC_i is the landed catch in year i. Legal encounters would be simply the difference between $E_{CNR,i}$ and $R_{CR,i}$. This equation assumes that the legal-sublegal encounter ratio does not change between CR and CNR fisheries. This assumption was necessary because of the lack of identification of legal- and sublegal-sized Chinook releases in CNR fisheries. However, the Fisheries Operation System (FOS) for salmon fisheries in British Columbia began recording legal- and sublegal-sized Chinook releases in troll fisheries in 2004.

Using FOS logbook data from NBC troll fisheries for years 2004-2008, a nonparametric Wilcoxon matched pair test of sublegal proportions at the management area-year stratification level (indicated by subscripts j and i, respectively) was used to test this assumption. With the same purpose, an ANCOVA was conducted with transformed proportions and year as covariate. In the latter analysis, the proportions of sublegal fish relative to the encountered fish (i.e., legal + sublegal) in CR (SL_{CR}) and CNR (SL_{CNR}) fisheries were transformed prior to the analysis as:

$$(SL_{CR})_{j,i} = \frac{\log_e(SL_{R,j,i}+1)}{\log_e(SL_{R,j,i}+1)+\log_e(L_{CR,j,i}+1)} \qquad \text{(Equation III.4.4)}$$

and

$$(SL_{CNR})_{j,i} = \frac{\log_e(SL_{R,j,i}+1)}{\log_e(SL_{R,j,i}+1)+\log_e(L_{CNR,j,i}+1)} \qquad \text{(Equation III.4.5)}$$

where SL_R is the number of sublegal releases, $L_{CR,j,i}$ is the number of legal-sized Chinook salmon kept for method 1 described below and the number of legal-sized Chinook salmon kept and legal-sized Chinook salmon released for method 2 described below, and $L_{CNR,i,j}$ is the number of legal-sized Chinook salmon released for method 1 described below and the number of legal-sized Chinook salmon released and the number of legal-sized Chinook salmon kept for method 2 described below.

For both statistical tests, two constraints were applied: (i) only data for years 2004-2008 were used since FOS began recording legal- and sublegal-sized Chinook releases in 2004; and, (ii) management area-years with less than 40 encounters were removed from the analysis. In addition, the sublegal-sized Chinook proportions were computed under two data schemes: (i) Method 1 used only legal-sized Chinook kept and sublegal-sized Chinook released in CR fisheries and legal- and sublegal-sized Chinook released in CNR fisheries; and, (ii) in addition to encounter categories used in Method 1, Method 2 included the legal-sized Chinook released in CR fisheries and legal-sized Chinook kept in CNR fisheries in the estimation of sublegal proportions. For clarification of Method 2, legal-sized Chinook are sometimes released in CR fisheries because they are damaged or considered of low value whereas legal fish are sometimes kept in CNR fisheries as a result of unauthorized fishing or the use of food fish licenses (*personal communication*; Bruce Patten, DFO, PBS, Nanaimo, BC). These two additional encounter categories, CR legal-sized Chinook releases and CNR legal-sized Chinook kept, are identifiable in FOS.

The Wilcoxon test showed significant differences between the sublegal proportions of CR and CNR periods either using Method 1 ($n = 13$; $z = 2.69$; $p = 0.007$) or Method 2 ($n = 13$; $z = 3.18$; $p = 0.001$). Similarly, the ANCOVA showed that sublegal proportions are marginally different ($df = 23$; $F = 3.64$; $p = 0.07$) between CR and CNR fisheries using Method 1 and significantly different at $\alpha = 0.05$ ($df = 23$; $F = 8.24$; $p = 0.009$) using Method 2. A comparison of the annual proportion of sublegal-sized Chinook in CR and CNR fisheries shows a pronounced (one order of magnitude greater in CNR fisheries) difference in this metric for both Method 1 and Method 2 in common years 2004-2008 (Table III.4.10).

As a result of the above-mentioned observations, incidental mortalities were computed as follows:

1. A correction factor of 1.67 was applied to NBC troll fisheries for 1999-2008. Corrections were exerted at two steps of the computation process: (a) when computing sublegal releases in CR fisheries; and, (b) when computing the sublegal encounters in CNR fisheries.
2. Given the potential differences in encounter patterns between CR and CNR fisheries, direct counts (as recorded in FOS) of legal- and sublegal-sized Chinook released during CNR fisheries were used for 2004 and later. Equation III.4.3 was used to derive sublegal- and legal-sized Chinook encounters prior to 2004.
3. Computation of the incidental mortality included both legal-sized Chinook released in CR fisheries and legal-sized Chinook kept in CNR fisheries (these can be non-trivial in some years; see Table III.4.10). These two categories of mortalities necessitate three additional steps to compute total incidental mortality: (a) compute legal-sized released incidental mortality in CR fisheries; (b) include legal kept in the CNR legal encounters; and, (c) separate CNR legal incidental mortality into legal released (i.e., legal-sized Chinook released times legal-sized Chinook mortality rate plus drop-off mortality) and legal-sized Chinook kept.
4. Validated catch determined through dockside monitoring replaced FOS catch data for 2005-2008 and was used to adjust incidental mortality assuming proportionality between LC and both legal and incidental mortality. LC determined through logbooks represented 90-98% of the validated catch in these years.

Table III.4.10. Annual Chinook encounters in CR and CNR fisheries for the NBC troll fishery (FOS query date: November 12, 2009), along with the proportions of sublegal-sized Chinook encountered as estimated by two methods (see text for details).

		Annual total			Sublegal proportion	
Fishery	Year	Legal kept	Sublegal released	Legal released	Method 1	Method 2
CR	2004	142,054	1,873	678	0.013	0.013
CR	2005	165,655	8,092	3,944	0.047	0.046
CR	2006	149,035	6,239	2,770	0.040	0.039
CR	2007	74,817	6,408	2,398	0.079	0.077
CR	2008	46,894	2,921	445	0.059	0.058
CNR	2004	2,401	4,870	26,128	0.157	0.146
CNR	2005	997	4,481	7,790	0.365	0.338
CNR	2006	11	732	1,051	0.411	0.408
CNR	2007	104	2,241	1,928	0.538	0.524

In addition, Chinook kept and vessel activity were cross-checked among several data sources (e.g. logbooks, phone-in, charter patrol inspections) to produce final catch estimates. These final catches can differ (generally higher) from the total legal kept reported in logbooks, in which case the finalized data are used to adjust proportionally incidental mortality values, which is similar to the procedure applied to validated catch (point iv above). Finalized catches replaced FOS catch data for years 1997-2004.

Encounters are multiplied by their respective incidental mortality rates (Table III.4.11; CTC 1997, 2004a). Legal-sized Chinook drop-off mortalities are added to legal-sized Chinook CNR mortalities (drop-off and legal kept) and legal-sized Chinook releases in CR fisheries to estimate total LIM while sublegal-sized Chinook CNR mortalities are added to sublegal-sized Chinook retention mortalities to estimate SIM.

Table III.4.11. LC, legal- and sublegal-sized Chinook encounters, and incidental mortality rates for the NBC troll fishery, 1999-2008. Legal-sized Chinook include legal-sized Chinook released in CR fisheries, legal-sized Chinook kept in CNR fisheries, and legal-sized Chinook released in CNR fisheries. Sublegal encounters include sublegal-sized Chinook released in CR and CNR fisheries after bias correction due to underreporting of releases.

Year	LC	Legal	Sublegal
1999	44,900	0	2,844[3]
2000	9,800	0	620[3]
2001	13,100	773[3]	1,165[3]
2002	103,038	5,979	3,734
2003	137,357	13,729	3,025
2004	167,508	29,188	10,979
2005	174,806	12,750	21,388
2006	151,485	3,832	11,641
2007	83,235	4,430	14,443
2008	52,147	1,936	5,962
IM Rates	0.017[1]	0.202[2]	0.237[2]

[1] Drop-off rate from CTC (1997).
[2] Drop-off rate + immediate mortality rate from CTC (1997).
[3] Values derived from 2002-2008 average Releases:LC ratios.

Table III.4.12. Estimated Chinook salmon LIMs and SIMs for the NBC troll fishery, 1999-2008.

Year	LIM Drop-off	LIM CNR[1]	LIM CR	LIM Total	SIM CNR[1]	SIM CR	SIM Total
1999	763	0	0	763	0	674	674
2000	167	0	0	167	0	147	147
2001	223	156	0	379	79	197	276
2002	1,752	1,351	0	3,102	46	839	885
2003	2,335	3,127	0	5,462	61	656	717
2004	2,848	7,675	137	10,660	1,927	675	2,602
2005	2,972	2,574	797	6,343	1,773	3,296	5,069
2006	2,575	223	560	3,359	290	2,469	2,759
2007	1,415	493	484	2,392	887	2,536	3,423
2008	886	337	90	1,314	257	1,156	1,413

[1] No CNR fisheries were prosecuted in 1999 and 2000.

Table III.4.13. Ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for NBC troll fishery, 1999-2008.

Year	LIM:LC	SIM:LC
1999	0.017	0.015
2000	0.017	0.015
2001	0.029	0.021
2002	0.030	0.009
2003	0.040	0.005
2004	0.064	0.016
2005	0.036	0.029
2006	0.022	0.018
2007	0.029	0.041
2008	0.025	0.027
Average	0.031	0.020

III.4.B.2 NBC Sport Fishery

Kept and released Chinook salmon in the NBC sport fishery are estimated from creel survey and voluntary lodge logbook programs from late May through mid September. Since less than 10% of released Chinook are sublegal size (R. McNicol, unpublished data), all estimated releases are considered legal size for the purposes of estimating incidental mortality. NBC sport legal releases per LC from 1999-2008 are shown in Table III.4.14, Table III.4.15, and Table III.4.16.

Table III.4.14. Total LC, legal- and sublegal-sized Chinook salmon releases, and IM rates for the NBC AABM sport fishery, 1999-2008.

Year	LC	Legal	Sublegal
1999	30,227	15,824	0
2000	22,100	24,573	0
2001	30,400	30,522	0
2002	47,100	42,226	0
2003	54,300	47,549	0
2004	74,000	116,741	0
2005	68,800	60,987	0
2006	64,500	32,480	0
2007	61,000	35,527	0
2008	43,500	10,649	0
IM Rates	0.036[1]	0.159[2]	0.159[2]

[1] Drop-off rate from CTC (1997).

[2] Drop-off rate (0.069) + immediate mortality rate (0.123) from CTC (1997).

Table III.4.15. Estimated Chinook salmon LIMs and SIMs in the NBC AABM sport fishery, 1999-2008.

Year	LIM Drop-off	LIM CR	LIM Total	SIM Total
1999	1,088	2,516	3,604	0
2000	796	3,907	4,703	0
2001	1,094	4,853	5,947	0
2002	1,696	6,714	8,410	0
2003	1,955	7,560	9,515	0
2004	2,664	18,562	21,226	0
2005	2,477	9,697	12,174	0
2006	2,322	5,164	7,48[illegible]	0
2007	2,196	5,649	7,845	0
2008	1,566	1,693	3,259	0

Table III.4.16. Estimated ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for NBC AABM sport fishery, 1999-2008.

Year	LIM:LC	SIM:LC
1999	0.119	NA
2000	0.213	NA
2001	0.196	NA
2002	0.179	NA
2003	0.175	NA
2004	0.287	NA
2005	0.177	NA
2006	0.116	NA
2007	0.129	NA
2008	0.075	NA
Average	0.167	NA

III.4.C WCVI AABM IM Estimates and 1999-2008 IM Ratios

III.4.C.1 WCVI Troll Fishery

Chinook salmon kept and released are estimated from a mandatory logbook and phone-in catch reporting system. All vessels are required to record the kept and released sublegal-and legal-sized Chinook in logbooks and daily logs are reported to a call center at the completion of a fishing trip, as per condition of fishing license. Logbook data are available in FOS since 1998 and legal- and sublegal-sized Chinook have been recorded separately since 2004. In addition, Chinook salmon kept and vessel activity are cross-checked among several data sources (e.g. logbooks, phone-in, charter patrol inspections) to produce final catch estimates. These final catches can be different from the total legal kept reported in logbooks, in which case the finalized data are used to proportionally adjust incidental mortality values.

Vélez-Espino et al. (2010) demonstrated there is a bias in Chinook releases recorded in logbooks during CR periods in the WCVI troll fishery, and that the underreporting bias was relatively stable over the last decade. The stability of this bias demonstrated a consistent underreporting of sublegal-sized Chinook releases (average correction factor of 1.67). Sparse CNR data in WCVI did not allow the independent computation of correction factors in CNR fisheries, but the application of the CR correction factor to CNR fisheries was considered as appropriate until more data are available.

The assumption that similar legal-sublegal ratios exist in CR and CNR fisheries for a given year has been necessary for CNR fisheries for years without legal-sublegal stratification of encounters (prior to 2004). Various statistical analyses of 2004-2008 time series showed significant differences in the legal-sublegal ratio between CR and CNR fisheries in NBC but a similar analysis has not been possible for the WCVI troll fishery due to insufficient data.

Hence, similar to the computation of incidental mortalities in NBC, four processes influenced the computation of incidental mortality in the WCVI troll fishery. First, corrections factors were applied in two steps of the computation process for 1999 and later: (*a*) when computing the number of sublegal releases in CR fisheries; and, (*b*) when computing the sublegal encounters in CNR fisheries. Second, direct counts (as recorded in FOS) of legal and sublegal Chinook salmon released during CNR fisheries were used for years 2004 and later. Third, computation of incidental mortality accounted for both, legal-sized Chinook released in CR fisheries and legal fish kept in CNR fisheries for years 2004 and later.

Encounters were multiplied by their respective incidental mortality rates (CTC 1997, 2004a) and LIMs and SIMs were estimated as for the NBC troll fishery (Section II.1.C). Table III.4.17, Table III.4.18, and Table III.4.19 summarize mortality data for 1999-2008.

Table III.4.17. Total LC, legal- and sublegal-sized Chinook salmon encounters, and incidental mortality rates for the WCVI troll fishery, 1999-2008. Legal-sized Chinook encounters include legal-sized Chinook released in CR fisheries, legal-sized Chinook kept in CNR fisheries, and legal-sized Chinook released in CNR fisheries. Sublegal-sized Chinook encounters include sublegal-sized Chinook released in CR and CNR fisheries after bias correction due to underreporting of releases.

Year	LC	Legal	Sublegal
1999	5,307	0	3,042
2000	63,400	0	17,300
2001	77,491	4,783	25,376
2002	132,921	6,939	19,958
2003	151,826	566	23,287
2004	169,128	1,495	14,772
2005	143,798	624	14,131
2006	104,004	4,029	13,278
2007	89,291	272	13,751
2008	90,170	193	9,987
IM Rates	0.017[1]	0.202[2]	0.237[2]

[1] Drop-off rate from CTC (1997).
[2] Drop-off rate + immediate mortality rate from CTC (1997).

Table III.4.18. Estimated Chinook salmon LIMs and SIMs for the WCVI troll fishery, 1999-2008. LIM CR includes legal-sized Chinook drop-off and release mortality in CR fisheries. LIM CNR includes legal-sized Chinook release mortality and legal-sized Chinook kept during CNR fisheries. SIM CNR includes sublegal-sized Chinook drop-off and release mortality in CNR fisheries. SIM CR includes sublegal-sized Chinook drop-off and release mortality in CR fisheries.

Year	LIM Drop-off	LIM CNR[1]	LIM CR	LIM Total	SIM CNR[1]	SIM CR	SIM Total
1999	90	0	0	90	0	721	721
2000	1,078	0	0	1,078	0	4,100	4,100
2001	1,317	1,312	0	2,629	336	5,678	6,014
2002	2,260	1,433	0	3,693	249	4,481	4,730
2003	2,581	409	0	2,990	7	5,512	5,519
2004	2,875	0	302	3,177	0	3,501	3,501
2005	2,445	0	126	2,571	0	3,349	3,349
2006	1,768	737	107	2,612	537	2,610	3,147
2007	1,518	0	55	1,573	0	3,259	3,259
2008	1,533	0	39	1,572	0	2,367	2,367

1 No CNR fisheries were prosecuted in 1999, 2000, 2004, 2005, 2007 and 2008.

Table III.4.19. Estimated ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for WCVI troll fishery, 1999-2008.

Year	LIM:LC	SIM:LC
1999	0.017	0.136
2000	0.017	0.065
2001	0.034	0.078
2002	0.028	0.036
2003	0.020	0.036
2004	0.019	0.021
2005	0.018	0.023
2006	0.025	0.030
2007	0.018	0.036
2008	0.017	0.026
Average	0.021	0.049

III.4.C.2 WCVI Sport Fishery

Kept and released Chinook in the WCVI sport fishery are estimated from creel survey and a voluntary lodge logbook programs from June through mid September. Creel surveyors interview anglers and examine catch at major landing sites. Effort surveys of the outside areas are determined by overflights through predefined fishing areas. The methodology is the same as that for the Strait of Georgia creel survey (English et al. 2002). Estimates of kept and released fish are produced for legal- and sublegal-sized Chinook when only minimum size limits occur. When size slot limits occur, kept and released estimates for legal-sized Chinook are estimated for each size restriction category. WCVI sport legal- and sublegal-sized Chinook releases per landed catch for 1999-2008 are shown in Table III.4.20, Table III.4.21, and Table III.4.22.

Table III.4.20. Total LC, legal- and sublegal-sized Chinook salmon releases, and incidental mortality rates for the WCVI AABM sport fishery, 1999-2008.

Year	LC	Legal	Sublegal
1999	31,106	NA[3]	NA[3]
2000	24,070	5,025	18,900
2001	40,636	8,295	17,035
2002	31,503	12,326	7,507
2003	26,825	23,156	6,333
2004	39,086	16,061	5,485
2005	50,681	19,323	4,571
2006	36,507	11,882	6,048
2007	46,323	5,973	15,590
2008	50,556	14,483	8,068
IM Rates	0.069[1]	0.192[2]	0.192[2]

1. Drop-off rate from CTC (1997).
2. Drop-off rate (0.069) + immediate mortality rate (0.123) from CTC (1997).
3. No data were collected in 1999. Values are derived from 2000-2008 average Releases:LC ratios.

Table III.4.21. Estimated Chinook salmon LIMs and SIMs in the WCVI AABM sport fishery, 1999-2008.

Year	LIM Drop-off	LIM CR	LIM Total	SIM Total
1999	2,146	2,126[1]	4,272	1,708[1]
2000	1,661	965	2,626	3,629
2001	2,804	1,593	4,397	3,271
2002	2,174	2,367	4,541	1,441
2003	1,851	4,446	6,297	1,216
2004	2,697	3,084	5,781	1,053
2005	3,497	3,710	7,207	878
2006	2,519	2,281	4,800	1,161
2007	3,196	1,147	4,343	2,993
2008	3,488	2,781	6,269	1,549

1. Data for 1999 were estimated from the average LIM:LC and SIM:LC ratios (see Table III.4.22).

Table III.4.22. Estimated ratios of LIMs and SIMs to LC and average ratios of LIMs and SIMs to LC for WCVI AABM sport fishery, 1999-2008.

Year	LIM:LC	SIM:LC
1999	0.137[1]	0.055[1]
2000	0.109	0.151
2001	0.108	0.080
2002	0.144	0.046
2003	0.235	0.045
2004	0.148	0.027
2005	0.142	0.017
2006	0.131	0.032
2007	0.094	0.065
2008	0.124	0.031
Average	0.137	0.055

[1]. Values for 1999 are simply the average of values for years 2000-2008 for which observed data are available.

III.5 MORTALITY TRENDS AND STATISTICS IN AABM FISHERIES

III.5.A SEAK AABM Fishery

The total LC and TIM in nominal fish (treaty + non-treaty) in the SEAK AABM fishery from 1985 to 2008 are shown in Figure III.5.1. Landed catch has averaged higher over the more recent period, while IM has been consistently lower after 1995. Most of the LC occurs in the troll fishery, followed by the sport and net harvest, respectively (Figure III.5.2).

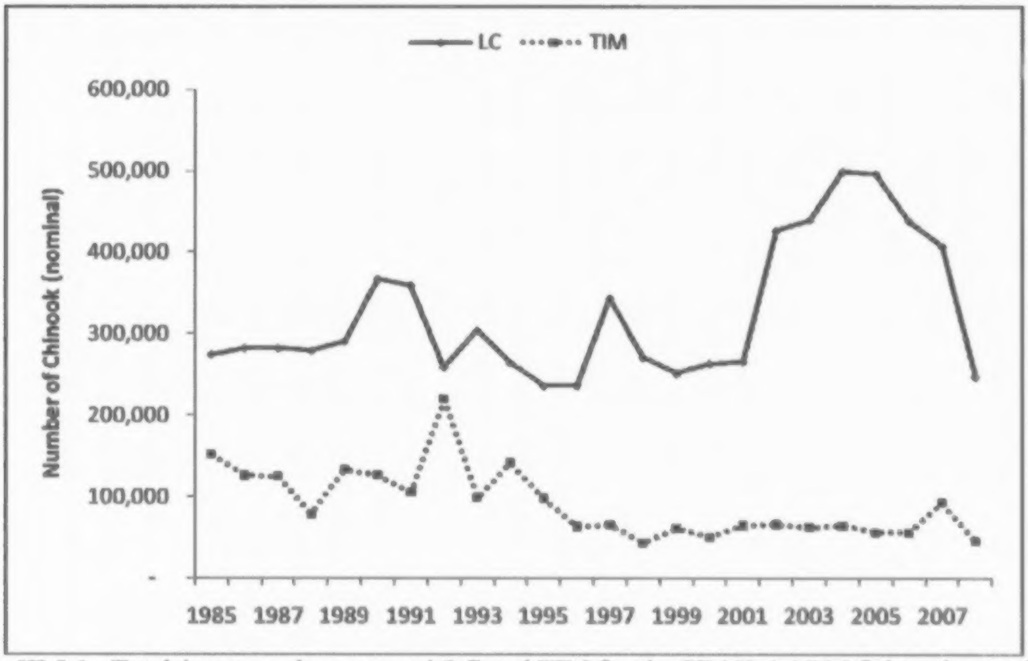

Figure III.5.1. Total (treaty and non-treaty) LC and TIM for the SEAK AABM fishery in nominal numbers of fish, 1985-2008.

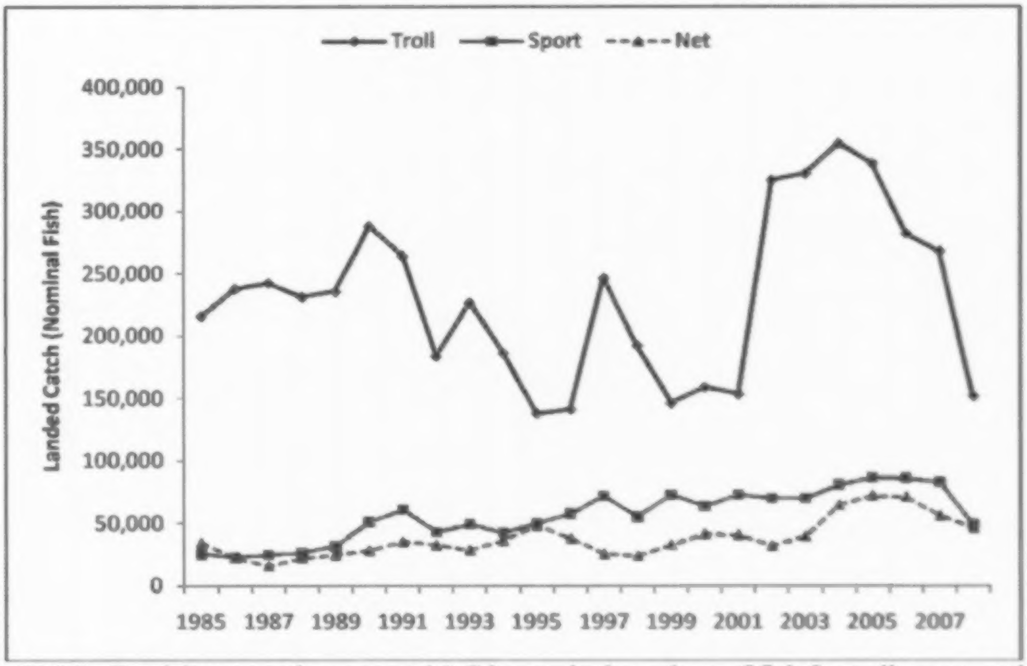

Figure III.5.2. Total (treaty and non-treaty) LC in nominal numbers of fish for troll, sport, and net gear in SEAK, 1985-2008.

III.5.A.1 SEAK Troll Fishery

In the SEAK troll fishery, LIM, SIM, and TIM have declined over the 1985-2008 time period (Figure III.5.3) even though landed catch has been higher in recent years. As a result, LIM:LC and SIM:LC ratios have declined over the time period (Figure III.5.4). The average TIM:LC ratio declined significantly ($P < 0.01$) from 0.34 for the 1985-1995 period to 0.15 for the 1999-2008 period (Figure III.5.5). Both LIM:LC and SIM:LC averages were also significantly ($P < 0.01$) lower in the latter period. The LIM:LC average declined from 0.10 to 0.06, and the SIM:LC from 0.24 to 0.10. These declines are attributed to management changes including: 1) a reduction in CNR fishing and 2) closures of areas of high Chinook salmon abundance during CNR fishing.

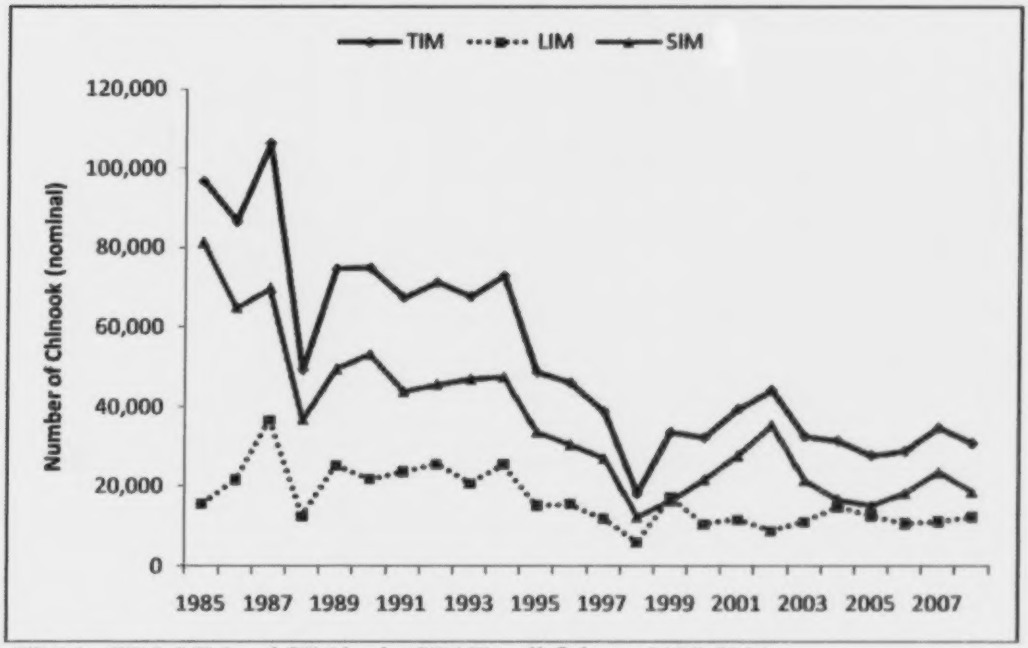

Figure III.5.3. TIM, LIM and SIM in the SEAK troll fishery, 1985-2008.

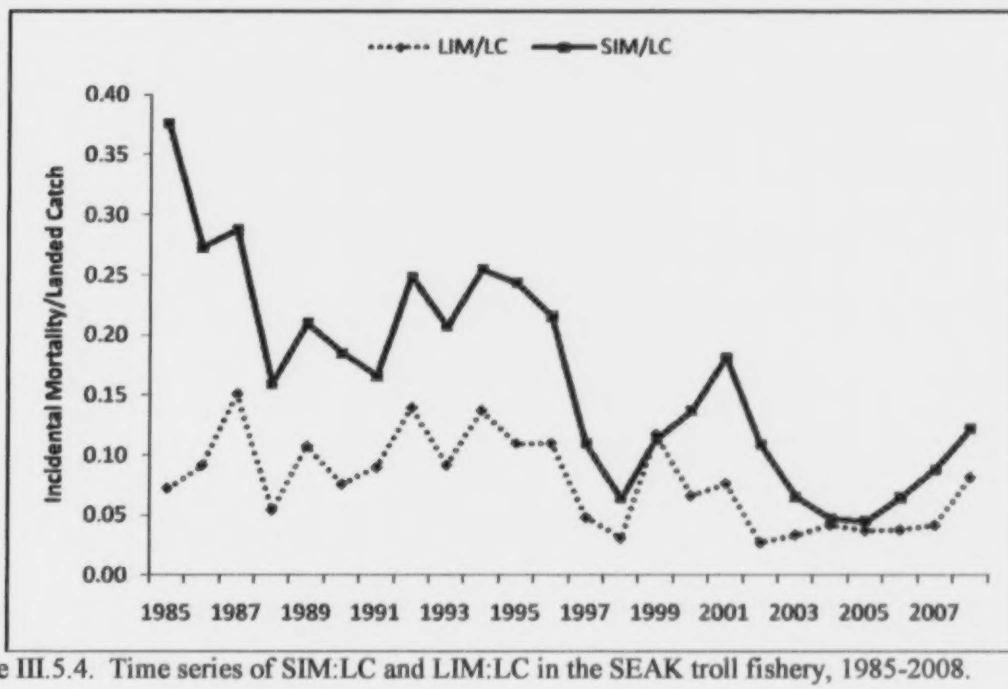

Figure III.5.4. Time series of SIM:LC and LIM:LC in the SEAK troll fishery, 1985-2008.

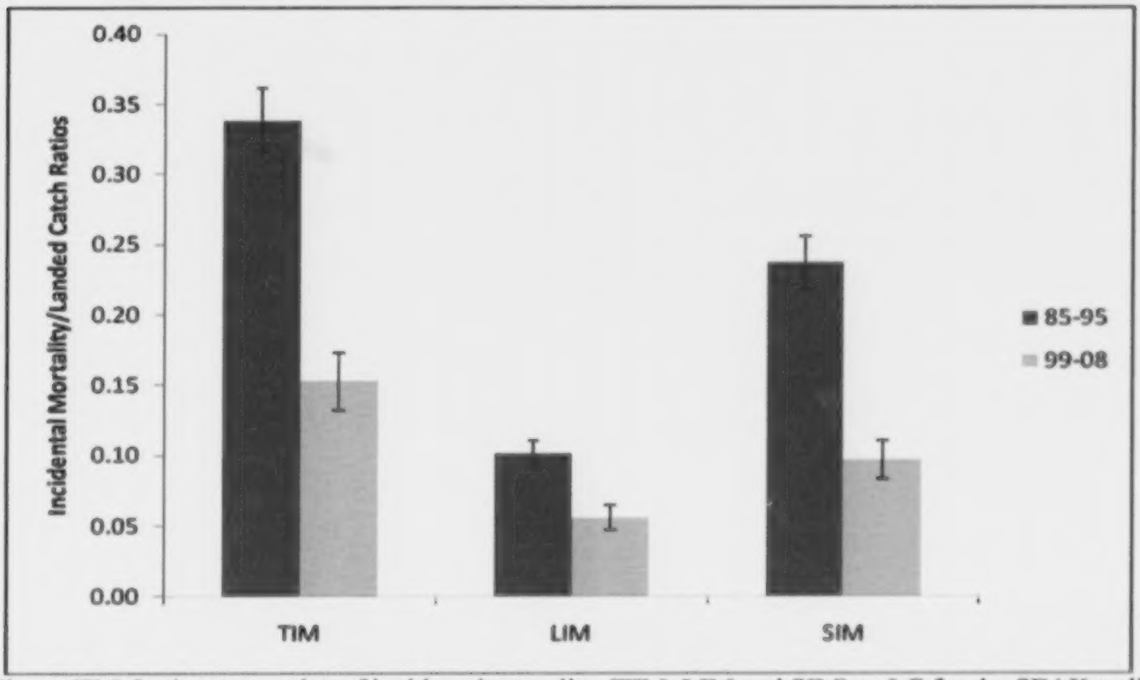

Figure III.5.5. Average ratios of incidental mortality (TIM, LIM and SIM) to LC for the SEAK troll fishery, 1985-1995 and 1999-2008. Error bars indicate the standard errors of the averages.

III.5.A.2 SEAK Sport Fishery

In the SEAK sport fishery, LIM, SIM, and TIM have increased slightly over the 1985-2008 time period (Figure III.5.6) commensurate with generally higher sport landed catch. However, the LIM:LC and SIM:LC have not shown a trend over the time series, other than a spike in the SIM:LC ratio in 1990 (Figure III.5.7). The average TIM:LC ratio has not changed significantly ($P > 0.10$) over the time period, averaging 0.26 for the 1985-1995 period and 0.24 for the 1999-2008 period (Figure III.5.8). Both LIM:LC and SIM:LC averages were also not significantly ($P > 0.10$) different between time periods. The LIM:LC average increased slightly from 0.09 to 0.10, and the SIM:LC decreased from 0.17 to 0.13. The lack of significant changes in IM ratios is consistent with the fact that, unlike the troll fishery, no directed management changes were implemented to reduce IM in the SEAK sport fishery.

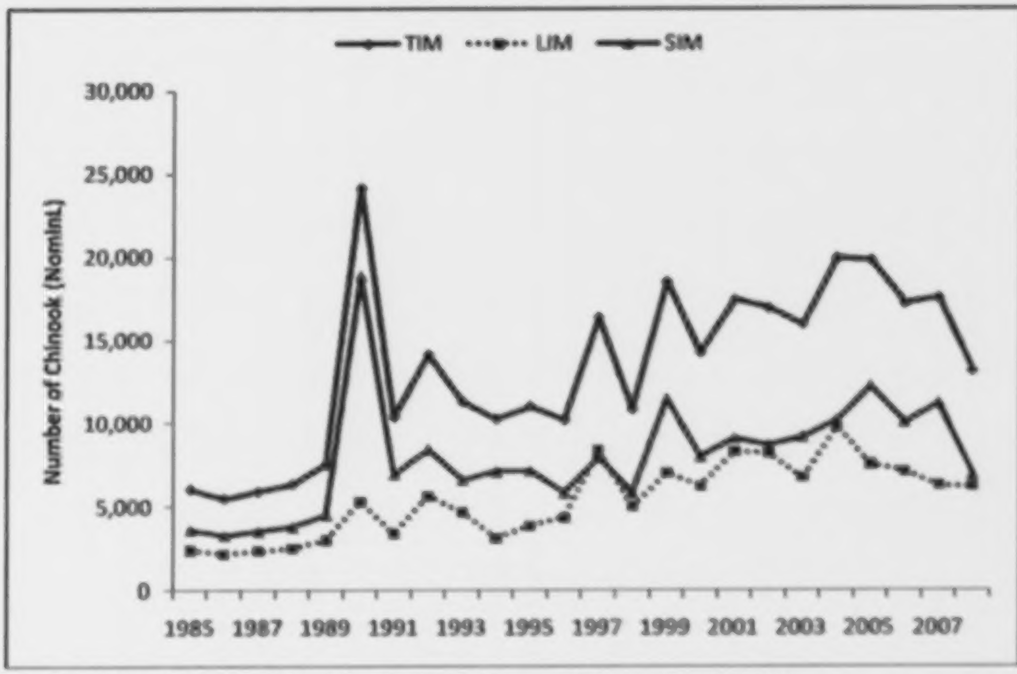

Figure III.5.6. TIM, LIM and SIM in the SEAK sport fishery, 1985-2008.

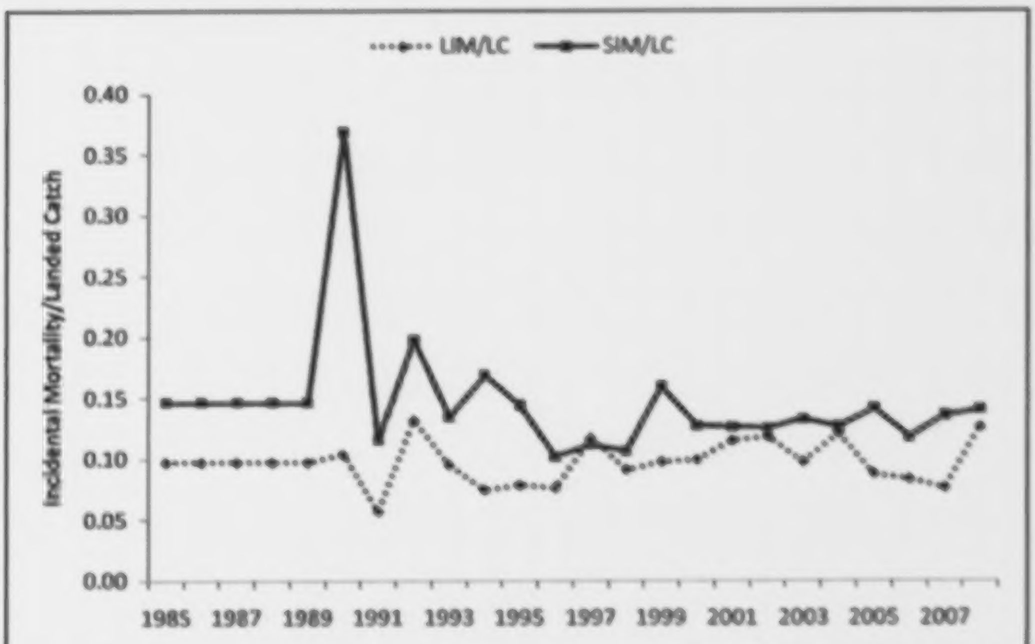

Figure III.5.7. Time series of SIM:LC and LIM:LC in the SEAK sport fishery, 1985-2008.

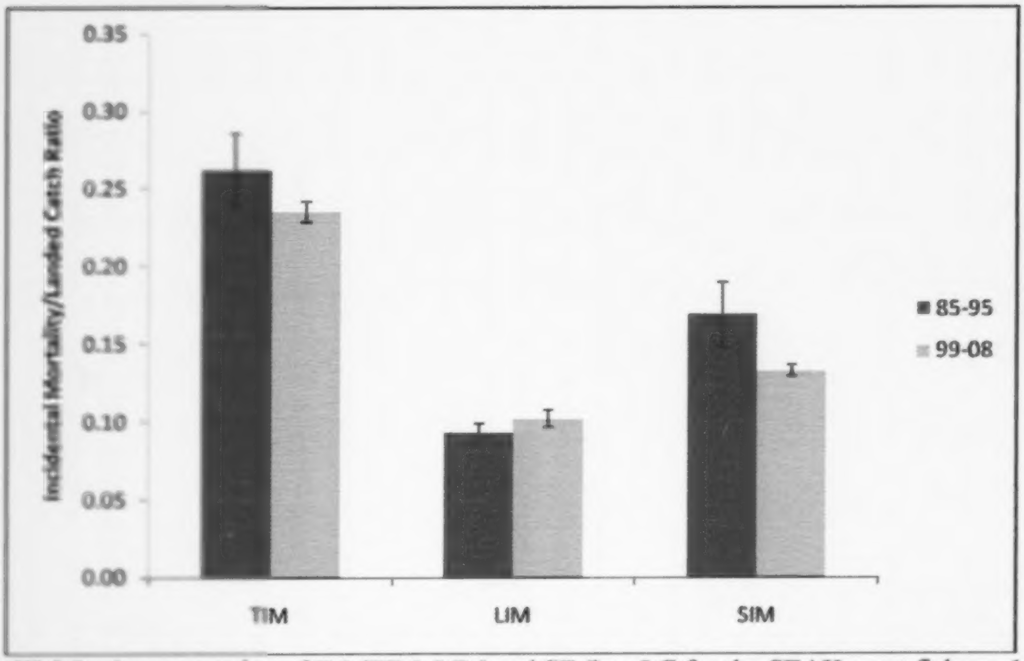

Figure III.5.8. Average ratios of IM (TIM, LIM and SIM) to LC for the SEAK sport fishery, 1985-1995 and 1999-2008. Error bars indicate the standard errors of the averages.

III.5.A.3 SEAK Net Fishery

In the SEAK net fishery, LIM, SIM, and TIM have declined markedly over the 1985-2008 time period (Figure III.5.9) even though landed catch has been higher in recent years. As a result, LIM:LC and SIM:LC ratios have declined over the time period (Figure III.5.10). The average TIM:LC ratio declined significantly ($P < 0.01$) from 1.44 for the 1985-1995 period to 0.22 for the 1999-2008 period (Figure III.5.11). Both LIM:LC and SIM:LC averages were also significantly ($P < 0.01$) lower in the latter period. The LIM:LC average declined from 0.26 to 0.03, and the SIM:LC from 1.30 to 0.20. Two factors have been identified as causing these declines: 1) the reduction in early season purse seine effort in district 104 to decrease the harvest of Skeena and Nass River sockeye salmon (high encounters of Chinook salmon occurred in this fishery prior to the reductions), and 2) lower pink salmon returns resulted in less purse seine effort in recent years (especially 2006 and 2008).

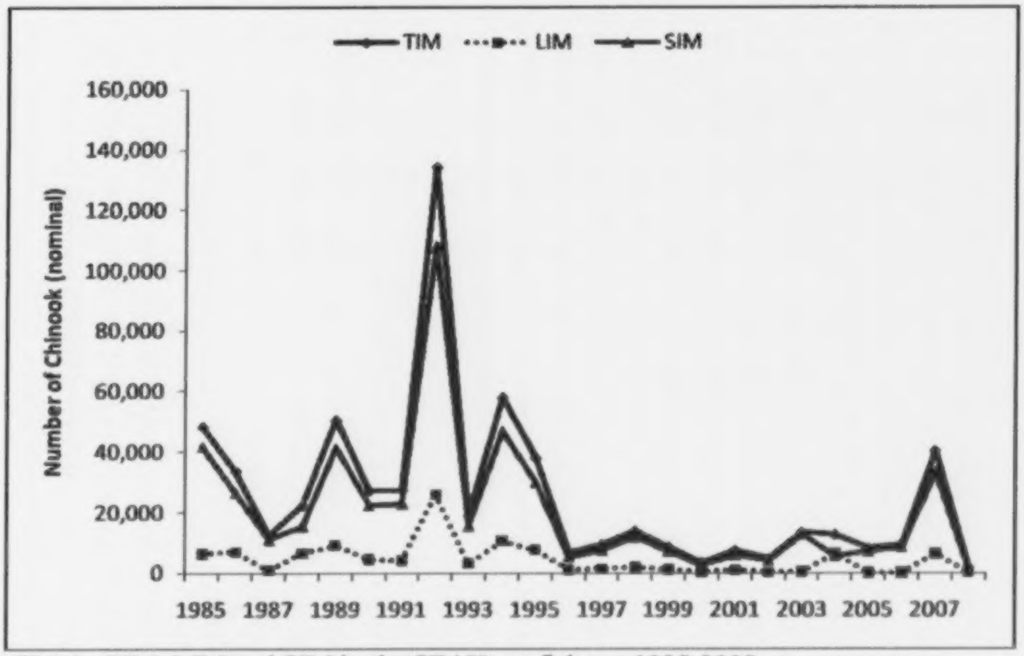

Figure III.5.9. TIM, LIM and SIM in the SEAK net fishery, 1985-2008.

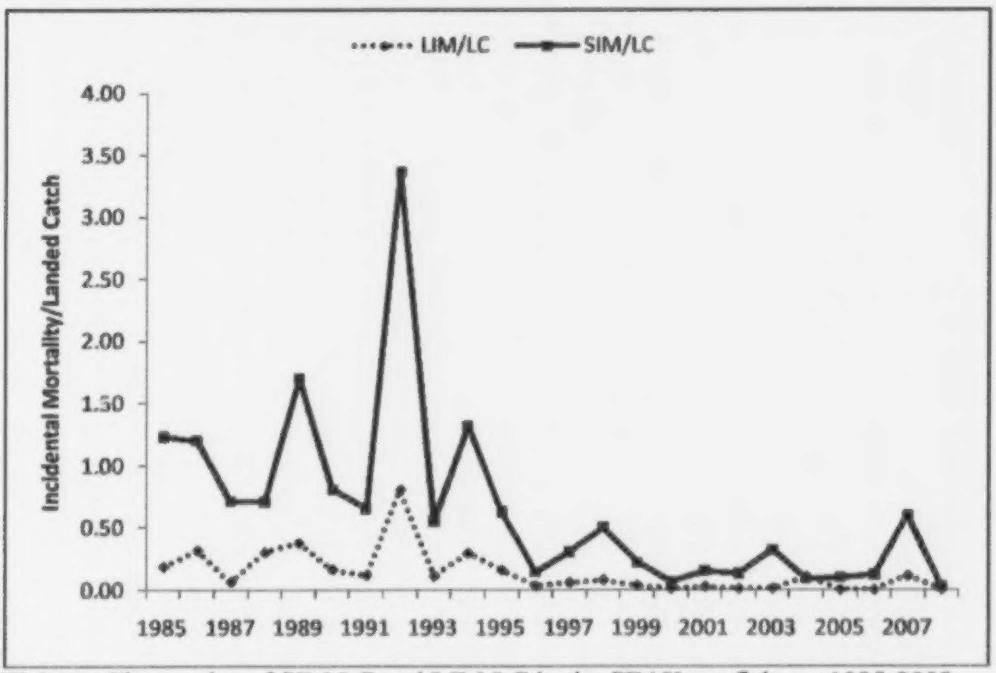

Figure III.5.10. Time series of SIM:LC and LIM:LC in the SEAK net fishery, 1985-2008.

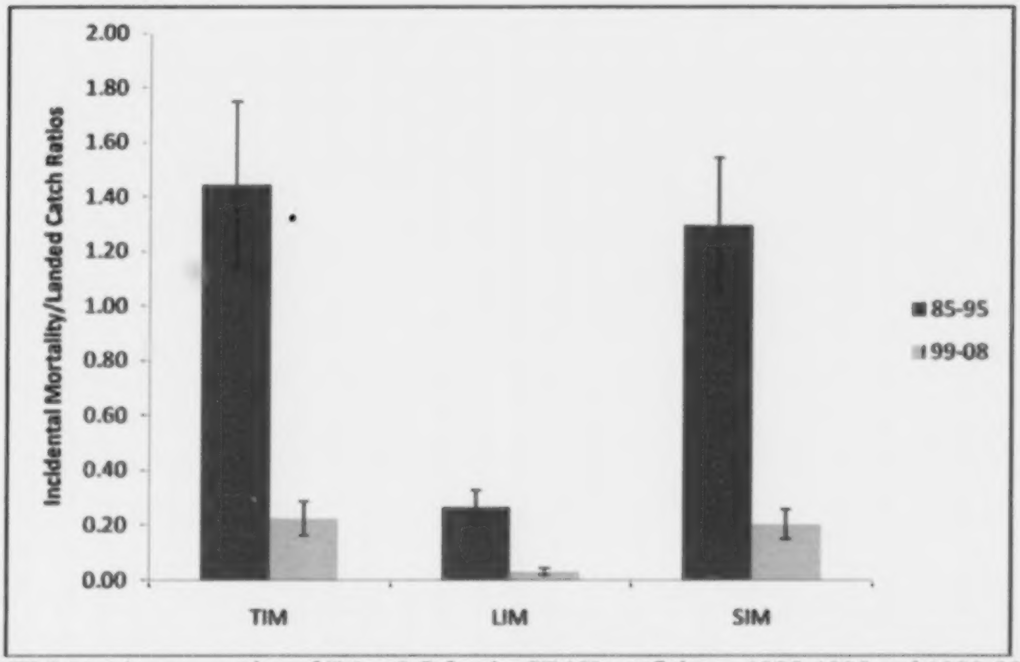

Figure III.5.11. Average ratios of IM to LC for the SEAK net fishery, 1985-1995 and 1999-2008. Error bars indicate the standard errors of the averages.

III.5.B NBC AABM Fishery

The LC and IM, in nominal fish, in the NBC AABM fishery for time periods 1985-1995 and 1999-2008 are shown in Figure III.5.12. LC was relatively stable (range: 159,428-228,331) from 1985 to 1994, showing a large decline to less than 80,000 fish in 1995. LC increased rapidly starting year 2000, almost reaching a quarter of a million in 2005. The last three years of the second time period exhibited pronounced declines in LC with about 100,000 Chinook in 2008. In general, IM has been lower during 1999-2008 relative to 1985-1995. Most of the harvest occurred in the troll fishery, although the sport harvest has been steadily increasing (Figure III.5.13). LC in troll and sport fisheries was similar (~50,000) for year 2008.

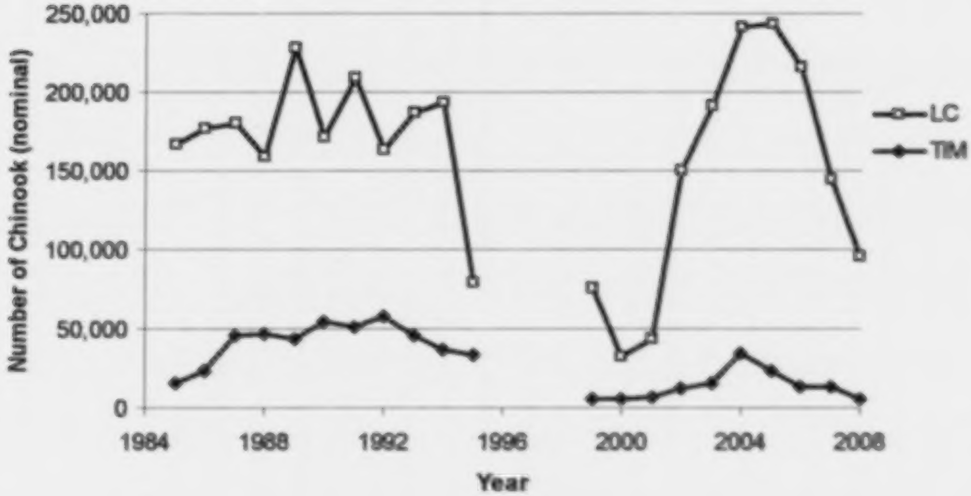

Figure III.5.12. Total LC and TIM for the NBC AABM fishery in nominal numbers of fish for time periods 1985-1995 and 1999-2008.

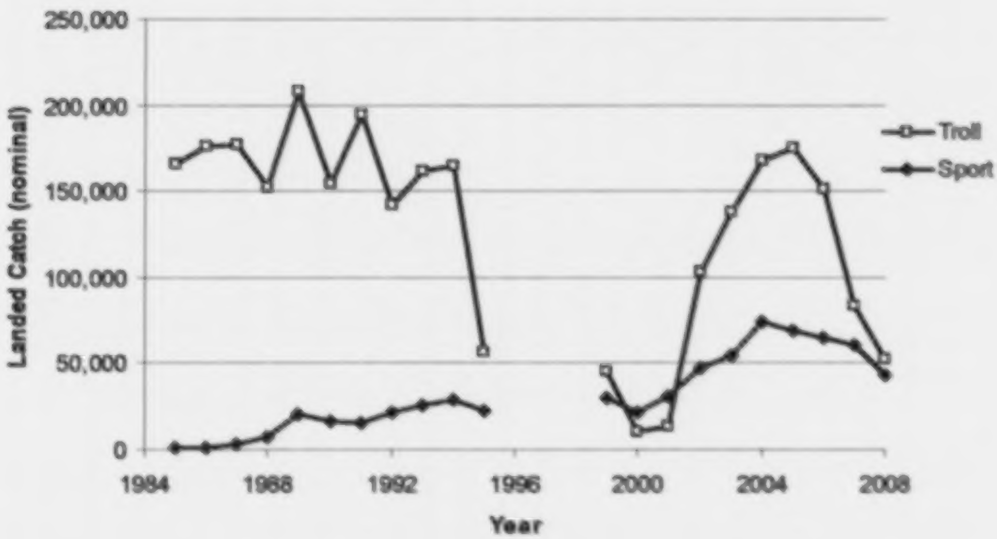

Figure III.5.13. Total LC in nominal numbers of fish for troll and sport gear in the NBC AABM fishery for time periods 1985-1995 and 1999-2008.

III.5.B.1 NBC Troll Fishery

In the NBC troll fishery, SIM and the cumulative TIM are substantially lower in 1999-2008 relative to 1985-1995 (Figure III.5.14) even though average landed catch is similar between time periods. The average TIM:LC ratio declined significantly ($P < 0.01$) from 0.26 for the 1985-1995 period to 0.06 for the 1999-2008 period (Figure III.5.15). The SIM:LC average was also significantly ($P < 0.01$) lower in the latter period with an average SIM:LC of 0.23 in 1985-1995 and 0.03 in 1999-2008. As is the case in all three AABMs, these declines are attributed to management changes including closures of areas with high sublegal Chinook salmon abundance during CNR fisheries, reduction in CNR fisheries and closures of areas of high Chinook salmon abundance during CNR fishing. The LIM:LC average remained at similar levels ($P > 0.10$) during the two time periods with average values of 0.028 and 0.032, respectively.

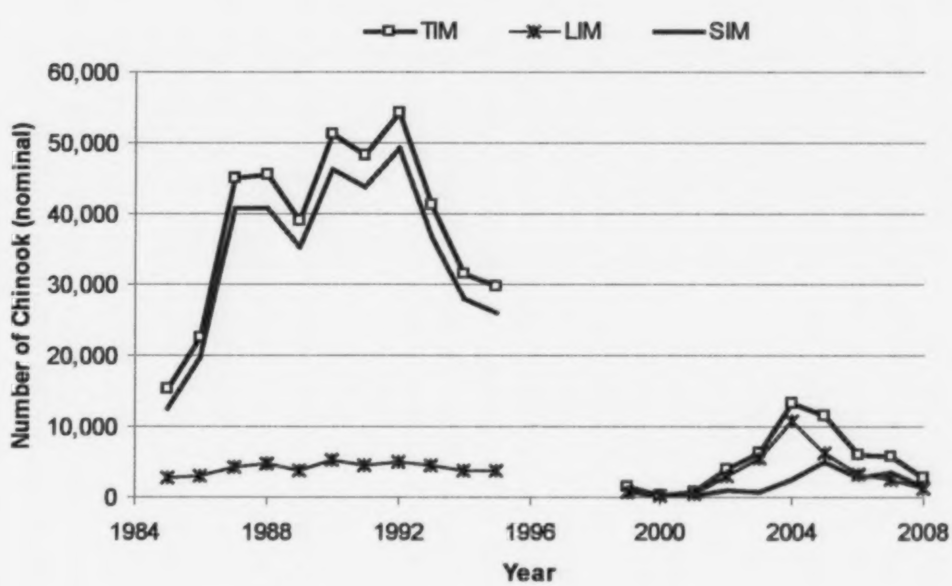

Figure III.5.14. TIM, LIM, and SIM in the NBC troll fishery for time periods 1985-1995 and 1999-2008.

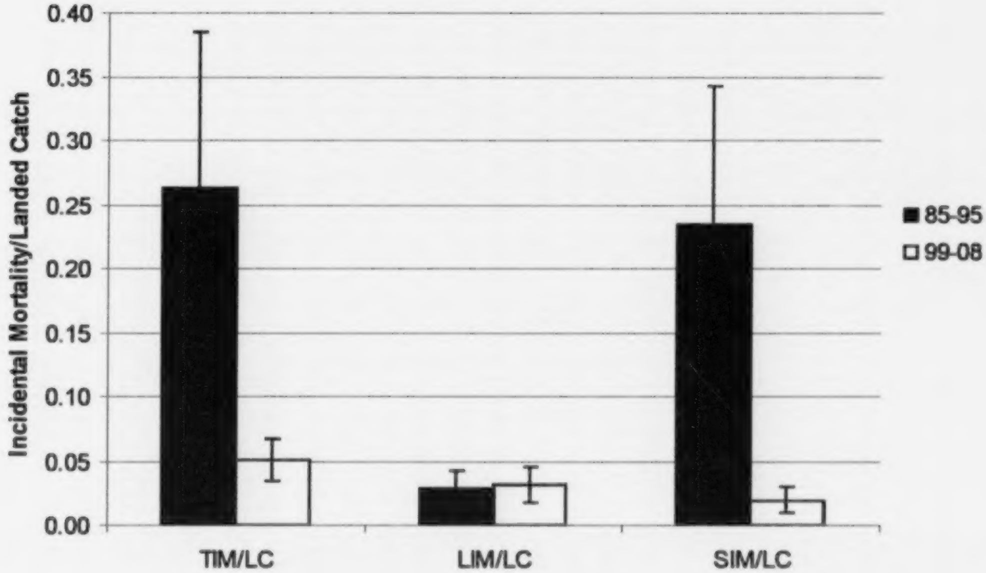

Figure III.5.15. Average ratios of IM to LC for the NBC troll fishery, 1985-1995 and 1999-2008. Error bars indicate the standard deviation.

III.5.B.2 NBC Sport Fishery

In NBC sport, IM was represented only by the LIM component. IM estimates for the base period were derived from the regression relationships derived from 1999-2008 data, defined in Section II.1.B.2. The LIM associated to the sport sector in NBC increased from 1985 to 2004, showing sharp and subsequent declines after that year (Figure III.5.16). In terms of mortality ratios, there were no significant differences ($P > 0.05$) in the average LIM:LC for NBC sport between time periods, averaging 0.18 in 1985-1995 and 0.17 in 1999-2008 (Figure III.5.17).

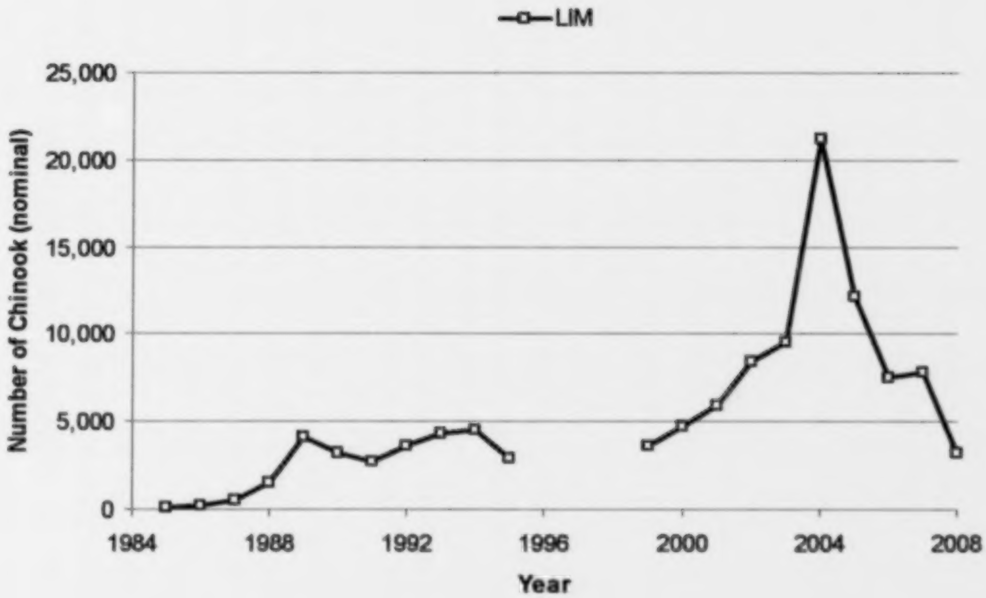

Figure III.5.16. LIM in the NBC sport fishery for time periods 1985-1995 and 1999-2008. Since there is no SIM in this fishery, TIM is equivalent to LIM.

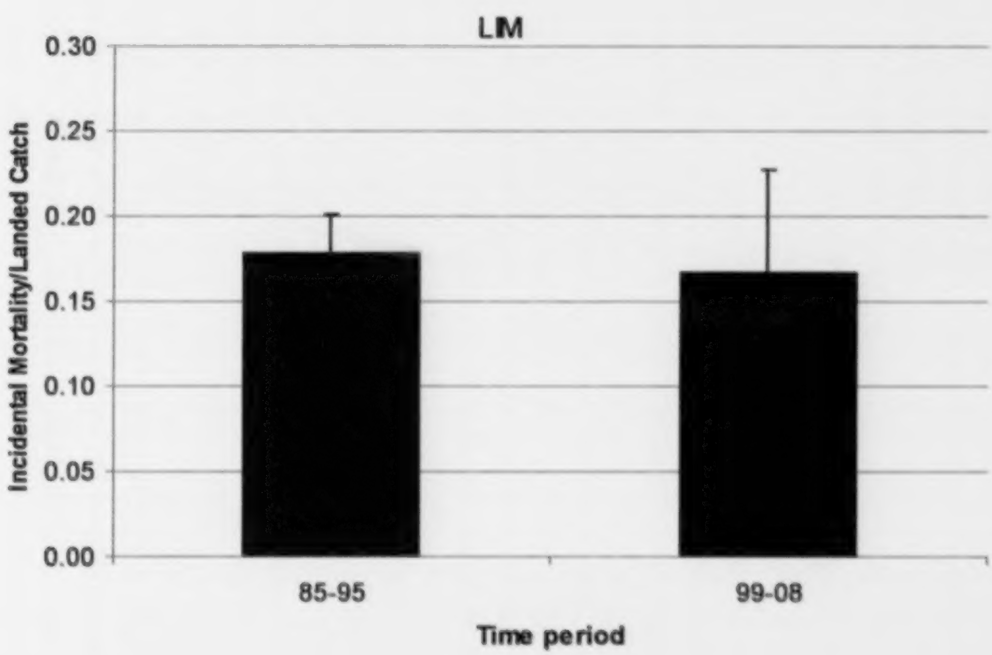

Figure III.5.17. Average ratios of IM to LC for the NBC sport fishery, 1985-1995 and 1999-2008. Error bars indicate the standard deviation

III.5.C WCVI AABM Fishery

LC and IM averaged lower in 1999-2008 (140,463 nominal fish) than in 1985-1995 (300,389 nominal fish) in WCVI. However, while the earlier period was characterized by a decline in both LC and TIM, the latter period showed an increase in LC and relatively stable levels of TIM (Figure III.5.18). Most of the harvest has occurred in the troll fishery, but the contribution of sport fisheries to total landed catch has increased in the last decade (Figure III.5.19).

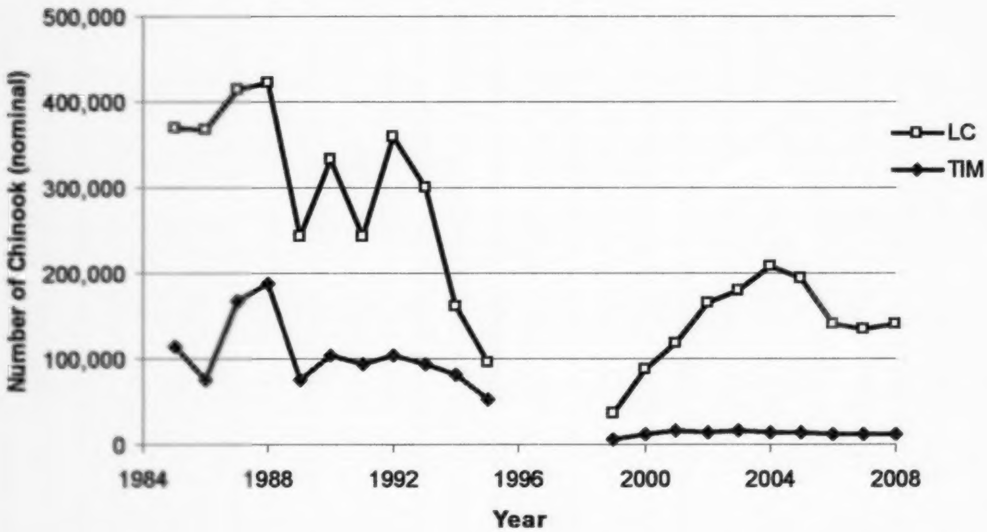

Figure III.5.18. Total LC and TIM for the WCVI AABM fishery in nominal numbers of fish for time periods 1985-1995 and 1999-2008.

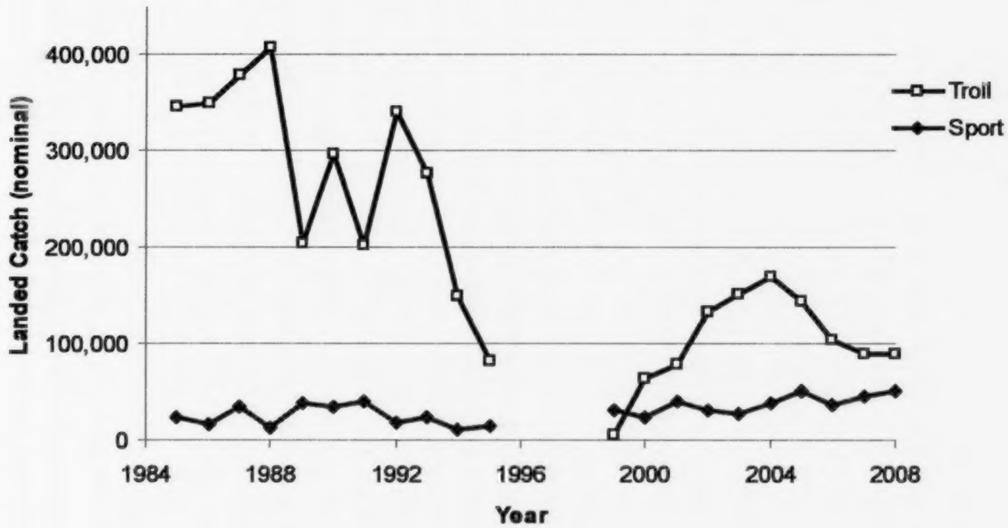

Figure III.5.19. Total LC in nominal numbers of fish for troll and sport gear in the WCVI AABM fishery for time periods 1985-1995 and 1999-2008.

III.5.C.1 WCVI Troll Fishery

In the WCVI troll fishery, SIM and the cumulative TIM were substantially lower in 1999-2008 relative to 1985-1995 (Figure III.5.20), partly due to the substantial LC reduction in the second time period. The average TIM:LC ratio declined significantly ($P < 0.01$) from 0.39 for the 1985-1995 period to 0.07 for the 1999-2008 period (Figure III.5.21). The SIM:LC average was also significantly ($P < 0.01$) lower in the latter period with an average SIM: LC of 0.36 in 1985-1995 and 0.05 in 1999-2008. These declines are attributed to management changes including reduction in CNR fisheries and closures of areas of high Chinook salmon abundance during CNR fishing. The LIM:LC average remained at similar levels ($P > 0.10$) during the two time periods with average values of 0.026 and 0.021, respectively.

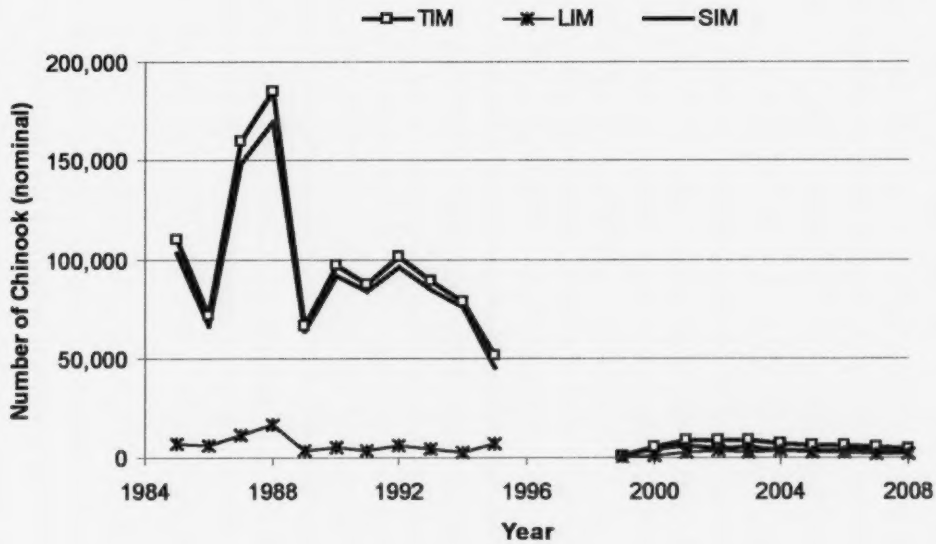

Figure III.5.20. TIM, LIM and SIM in the WCVI troll fishery for time periods 1985-1995 and 1999-2008.

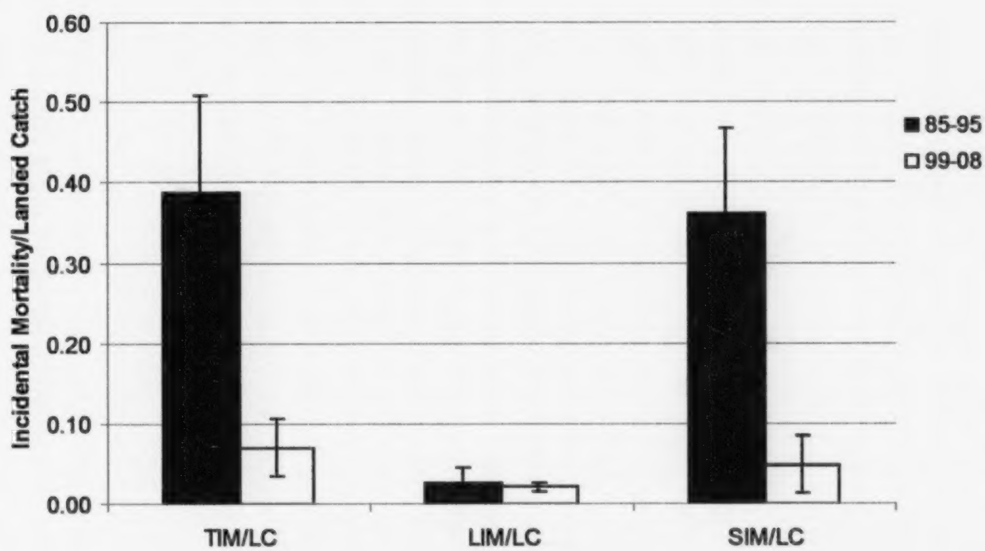

Figure III.5.21. Average ratios of IM to LC for the WCVI troll fishery, 1985-1995 and 1999-2008. Error bars indicate standard deviations.

III.5.C.2 WCVI Sport Fishery

In the WCVI sport fishery, LIM and the cumulative TIM averaged higher over the 1999-2008 time period relative to 1985-1995 (Figure III.5.22), partly due to a generally higher sport landed catch. SIM averaged higher in 1999-2008 (1890) than in 1985-1995 (1119). However, the average TIM:LC ratio (~0.19) did not change between the two time periods (Figure III.5.23). Likewise, SIM:LC averages (~0.05) and LIM:LC averages (~0.14) were similar between the two time periods. Note that SIM:LC ratios did not change during 1985-1995 as a result of base-period SIMs being estimated from the average SIM:LC ratio for 1999-2008. The lack of significant changes in LIM:LC ratios is consistent with the fact that, unlike the troll fishery, no directed management effort has been implemented to reduce IM in the WCVI sport fishery.

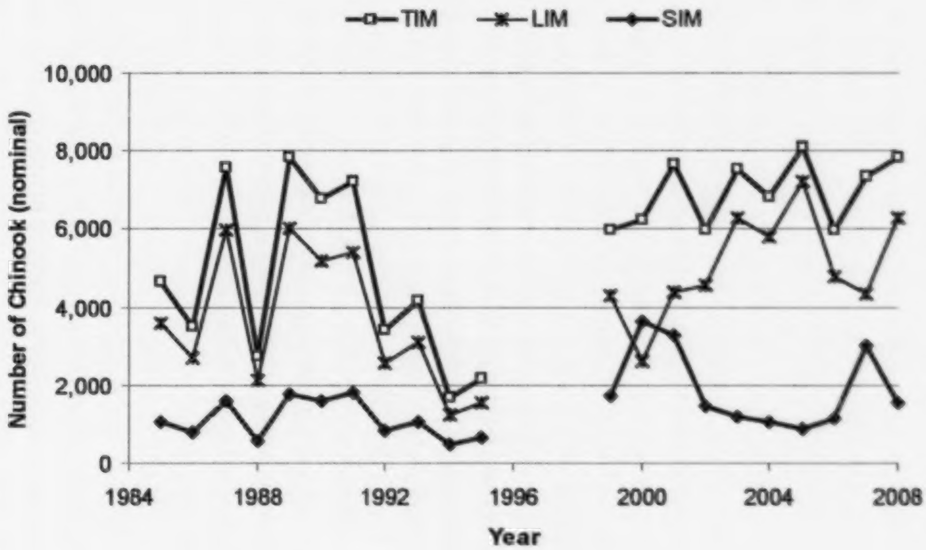

Figure III.5.22. TIM, LIM and SIM in the WCVI sport fishery for time periods 1985-1995 and 1999-2008.

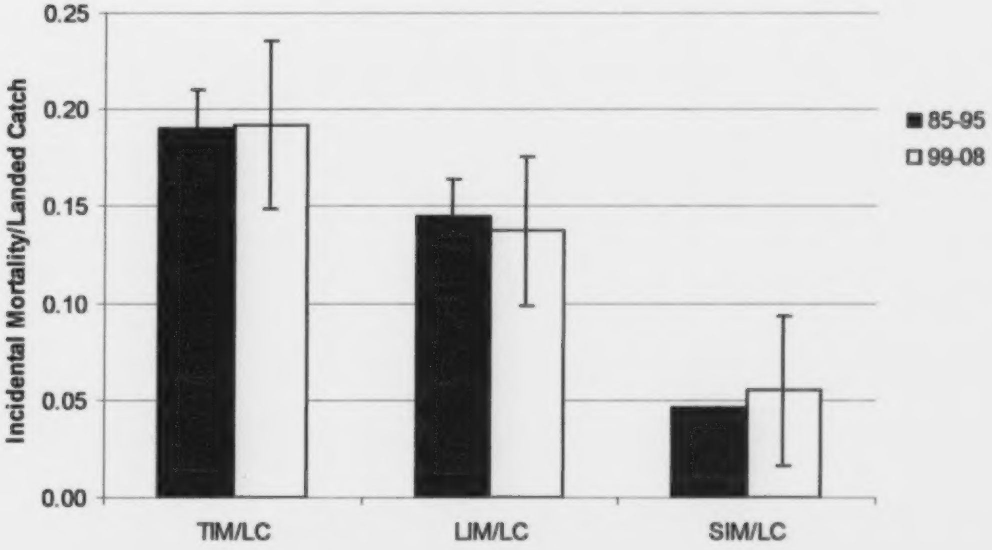

Figure III.5.23. Average ratios of IM to LC for the WCVI sport fishery, 1985-1995 and 1999-2008. Error bars indicate the standard deviation. Note that standard deviation is zero for SIM 1985-1995 due to the indirect method used to compute SIM (see Section II.2.D).

III.6 APPROACHES FOR ANNUAL PRESEASON AND POST-SEASON ESTIMATION OF TIM

The 2008 Agreement directs the CTC to evaluate the accuracy of preseason predictions of incidental mortality. Paragraph 2(d) of Appendix A to Annex IV, Chapter 3, of the Agreement states:

"*Evaluate the accuracy of preseason predictions of incidental mortalities, review assumptions, and investigate methods for improving estimates of total mortality in AABM and ISBM fisheries*".

In addition to preseason predictions, the CTC will need to estimate annually the IM in AABM fisheries that do not have validated annual estimates as per Section III.2 of this report. The TMWG has used average historical relationships between LC and IM for 1985-1995 for the computation of Table 1, as stipulated by the 2008 Agreement, and for 1999-2008 in its analysis of the potential effects of implementation of TM management in Section IV of this report. However, the average may not be the best predictor or estimator of IM as it does not account for interannual variation in the IM:LC ratios.

In this section, the TMWG examines the use of linear regression models, using historical information and relationships of IM or IM:LC to factors such as LC and preseason AI to determine if these models can improve annual estimates of IM relative to average values. Measures of TIM as well as LIM and SIM were considered, as better statistical relationships may be indicated for TIM than for the component LIM and SIM. However, for both preseason prediction and post-season assessment, estimation of TIM will require an additional step of allocating the TIM to the component legal and sublegal categories.

III.6.A SEAK AABM Fishery

A five-step approach was used to assess regression models for improving annual predictions and estimates of IM for SEAK using 1999-2008 data. First, potential predictors were correlated with measures of IM as an exploratory data analysis to identify potential regression models. Second, the regression analyses for "promising" parameters were carried out and evaluated for statistical significance. Third, the absolute deviations from observed IM were calculated for estimates derived from the regression models and for estimates derived using average IM:LC ratios for 1999-2008. Fourth, the sum and average of the absolute deviations were compared between the regression and average approaches using two-sample t-tests. Fifth and finally, a jackknife analysis was used to compare the predictive capability of the regression models to the 10-year averages.

Five potential prediction parameters were identified for IM in SEAK component fisheries. For all gear types, LC and preseason AI were evaluated for relationships for TIM, SIM, LIM and the associated IM:LC ratios. The non-vulnerable (NV) AI and the non-vulnerable:vulnerable (NV:V) ratio were also evaluated for relationships with SIM and SIM:LC for all gear types. For the net sector, SEAK pink salmon harvest was also included as an index of annual variation in purse seine effort.

III.6.A.1 SEAK Troll Fishery

The data used for SEAK troll are shown in Table III.6.1. The LC and preseason AI were highly correlated for the SEAK troll fishery ($r = 0.974$; Table III.6.2). As a result, correlation between measures of IM and LC and preseason AI were similar. Both were strongly and negatively correlated with IM:LC ratios. The negative correlation is probably reflective of reduced CNR fishing during periods of higher AI and LC. The NV_AI was not significantly correlated with measures of SIM, but the NV:V ratio was strongly correlated with SIM:LC.

The highest correlation for an IM parameter was -0.951 for TIM:LC and LC (Table III.6.2). For LIM measures, the highest correlation was -0.868 for LIM:LC and LC. For SIM measures, the highest correlation was -0.854 for SIM:LC and preseason AI. These sets of parameters were thus used to develop regression models.

Table III.6.1. PSC Chinook Model preseason AI (PreAI), non-vulnerable (NV) AI, and ratio of non-vulnerable to vulnerable; and total (treaty + non-treaty) estimates of LC, LIM, SIM and TIM, in nominal numbers, for the SEAK troll fishery, 1999-2008.

Year	PreAI	NV_AI	NV:V	LC	LIM	SIM	TIM
1999	1.15	0.98	0.47	146,219	17,101	16,419	29,115
2000	1.14	0.94	0.64	158,717	10,483	21,726	26,380
2001	1.14	1.15	0.62	153,280	11,668	27,697	31,933
2002	1.74	1.34	0.59	325,308	8,787	35,345	34,649
2003	1.79	1.90	0.35	330,692	11,085	21,501	26,817
2004	1.88	1.41	0.41	354,658	14,742	16,618	26,901
2005	2.08	1.57	0.36	338,446	12,572	15,151	23,658
2006	1.69	1.21	0.42	282,315	10,619	18,178	23,920
2007	1.60	1.17	0.35	268,149	11,136	23,535	28,356
2008	1.07	0.78	0.55	151,926	12,336	18,472	25,852
Average	1.53	1.24	0.48	250,971	12,053	21,464	27,758

Table III.6.2. Bivariate correlations (r) of LC, preseason AI (PreAI), NV_AI (post-season), NV:V, and measures of IM for the SEAK troll fishery, 1999-2008. Numbers in bold indicate correlations greater than 0.64, which are significant ($P < 0.05$, uncorrected for multiple comparisons).

Category	LC	PreAI	NV_AI	NV:V
LC	—	**0.974**	--	--
AI	**0.974**	—	--	--
TIM	-0.130	-0.233	--	--
LIM	-0.229	-0.164	--	--
SIM	0.021	-0.091	0.026	0.516
TIM:LC	**-0.951**	**-0.943**	--	--
LIM:LC	**-0.868**	**-0.822**	--	--
SIM:LC	**-0.825**	**-0.854**	-0.617	**0.848**

All three regressions were highly significant ($P < 0.005$; Table III.6.3). The regression estimates fit the observed data better than the estimates from the average ratios (Figure III.6.1). The regression of TIM:LC with LC had the best fit (adjusted $R^2 = 0.89$). The LIM:LC with LC regression and the SIM:LC with preseason AI regression had adjusted R^2 of 0.722 and 0.691, respectively.

Table III.6.3. Summary of parameter estimates of linear regressions of IM ratios in the SEAK troll fishery. Regressions have the form: IM:LC = a + b (Predictor).

IM Ratio	Predictor	*P* regress	a	SE(a)	*P* (a)	b	SE(b)	*P* (b)	Adjusted R^2
TIM:LC	LC	<.001	0.271	0.018	<.001	-5.8E-7	6.6E-8	<.001	0.892
LIM:LC	LC	0.001	0.126	0.015	<.001	-2.8E-7	5.7E-8	0.001	0.722
SIM:LC	AI	0.002	0.250	0.034	<.001	-0.100	0.022	0.002	0.696

The regression derived estimates of IM had significantly ($P < 0.01$) lower average absolute deviations from observed measures of IM for TIM, LIM, and SIM (Figure III.6.1). The TIM:LC regression had the lowest average deviations from the observed values at 11.6%, versus 16.8% for the LIM:LC regression and 11.6% for the SIM:LC regression. However, when LIM and SIM annual estimates derived from the respective regression were summed (in TCEs), the deviation from the observed TIM in TCEs was lower (11.2%) relative to those derived directly from the TIM:LC regression.

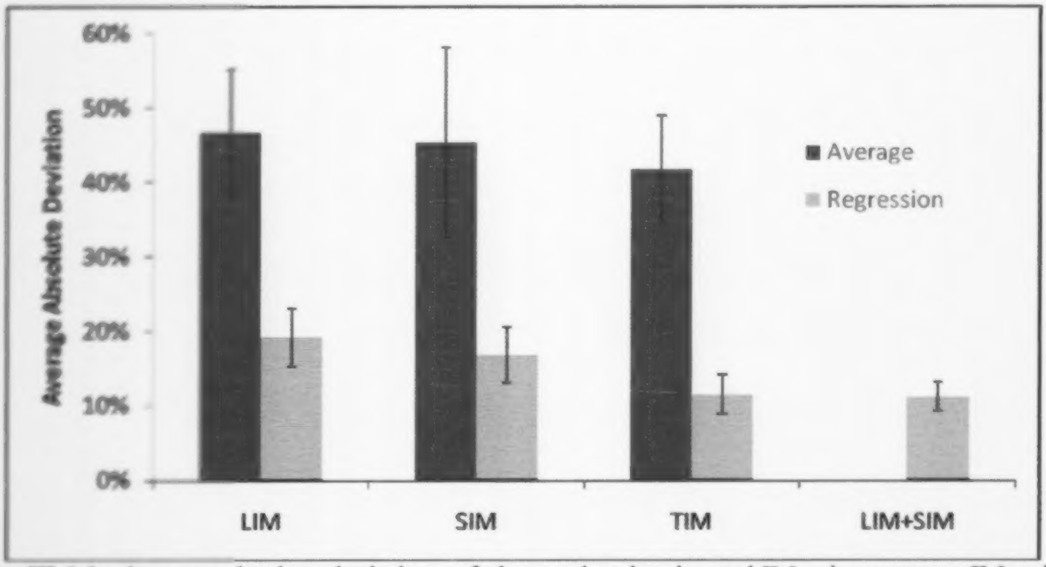

Figure III.6.1. Average absolute deviations of observed and estimated IM using average IM ratios and regression-derived IM ratios for the SEAK troll fishery, 1999-2008.

The jackknife procedure provided predictions of IM for each year using average values and regression equations generated excluding the year predicted. For TIM, LIM, and SIM, the regression equations for IM:LC provided better predictions than did the use of IM:LC averages (Figure III.6.2). Average absolute deviations were 14% for the regression model, versus 46% for the average for TIM; 24% for the regression model, versus 35% for the average for LIM; and 21% for the regression model, versus 50% for the average for SIM.

Based on these analyses, the regression relationships of IM with LC and preseason AI to the IM:LC ratio are superior to the use of the average IM:LC ratios both for predicting expected IM for the SEAK troll fishery, and for evaluating post-season IM in years for which estimates from a valid sampling program are not available. Although the direct estimate of TIM had lower absolute deviations than either SIM or LIM estimates, the fact that the deviations from observed TIM are lowest when SIM and LIM regression estimates are summed (Figure III.6.1) supports the use of these component estimates, as they also provide needed information to partition TIM into SIM and LIM.

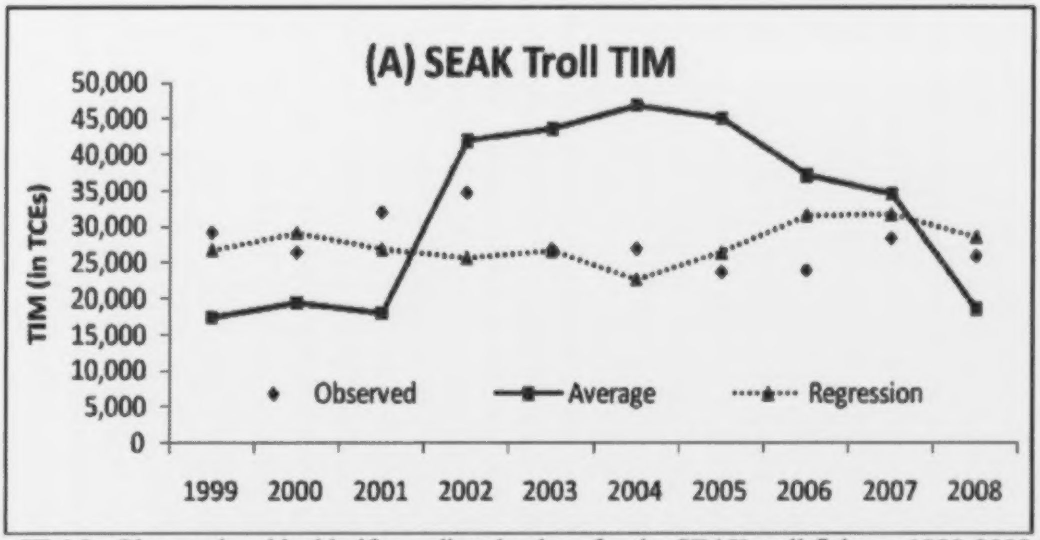

Figure III.6.2. Observed and jackknife predicted values for the SEAK troll fishery, 1999-2008 for: (A) TIM from the TIM:LC with LC regression and TIM:LC average; B) LIM from the LIM:LC with LC regression and LIM:LC average; and (C) SIM from the SIM:LC with AI regression and SIM:LC average.

III.6.A.2 SEAK Sport Fishery

The data used for SEAK sport are shown in Table III.6.4. The LC and preseason AI were significantly correlated for the SEAK sport fishery ($r = 0.695$; Table III.6.5), but less than seen for the troll fishery. The highest correlations for IM measures were with LC. The highest correlation for TIM measures was TIM with LC with an r of 0.800. For sublegal-sized Chinook, SIM was most strongly correlated with LC with an r of 0.841. For LIM measures, LIM:LC with LC had the highest correlation with an r of -0.641. These three sets of parameters were thus used to develop regression models.

Table III.6.4. PSC Chinook Model preseason AI (PreAI), non-vulnerable (NV) AI, and ratio of non-vulnerable to vulnerable; and total (treaty + non-treaty) estimates of LC, LIM, SIM and TIM, in nominal numbers, for the SEAK sport fishery, 1999-2008.

Year	PreAI	NV_AI	NV:V	LC	LIM	SIM	TIM
1999	1.15	0.98	0.47	72,081	7,036	11,469	18,504
2000	1.14	0.94	0.64	63,173	6,261	8,014	14,275
2001	1.14	1.15	0.62	72,291	8,316	9,110	17,425
2002	1.74	1.34	0.59	69,537	8,230	8,699	16,929
2003	1.79	1.90	0.35	69,370	6,767	9,205	15,972
2004	1.88	1.41	0.41	80,572	9,761	10,175	19,936
2005	2.08	1.57	0.36	86,575	7,569	12,248	19,817
2006	1.69	1.21	0.42	85,794	7,133	10,075	17,208
2007	1.60	1.17	0.35	82,848	6,302	11,237	17,539
2008	1.07	0.78	0.55	49,265	6,223	6,929	13,152
Average	1.53	1.24	0.48	73,151	7,360	9,716	17,076

Table III.6.5. Bivariate correlations (r) of LC, preseason AI (PreAI), NV_AI (post-season), NV:V, and measures of IM for the SEAK sport fishery, 1999-2008. Numbers in bold indicate correlations greater than 0.64, which are significant ($P < 0.05$, uncorrected for multiple comparisons).

Category	LC	PreAI	NV_AI	NV:V
LC	—	**0..695**	–	–
AI	**0.695**	—	–	–
TIM	**0.800**	0.613	–	–
LIM	0.377	0.418	–	–
SIM	**0.847**	0.527	0.362	**-0.679**
TIM:LC	**-0.678**	-0.398	–	–
LIM:LC	**-0.641**	-0.302	–	–
SIM:LC	-0.181	-0.256	-0.194	-0.211

All three regressions were significant ($P < 0.05$; Table III.6.6). The regression of SIM with LC had the best fit (adjusted $R^2 = 0.68$). The TIM with LC regression and the LIM:LC with LC regressions had adjusted R^2 of 0.595 and 0.337, respectively.

Table III.6.6. Summary of parameter estimates of linear regressions of IM ratios in the SEAK sport fishery. Regressions have the form: IM:LC = a + b (Predictor).

IM Ratio	Predictor	P regress	a	SE(a)	P (a)	b	SE(b)	P (b)	Adjusted R^2
TIM:LC	LC	<.01	5073	2382	0.066	0.122	0.322	<.01	0.595
LIM:LC	LC	0.046	0.173	0.030	<.001	-9.6E-7	4.1E-7	0.046	0.337
SIM:LC	LC	<.01	823	1992	0.683	0.122	0.027	<.01	0.683

The regression derived estimates of IM had consistently lower average absolute deviations from the observed than did estimates from average IM:LC ratios (Figure III.6.3.). However, the differences between the regression estimates and the average ratio estimates were significant ($P < 0.01$) for SIM, and not for LIM or TIM ($P > 0.25$). The estimates of nominal TIM from summed estimates of nominal LIM and SIM had lower average absolute deviations (5.4%) than estimate of TIM from the TIM regression (6.1%: Figure III.6.3.).

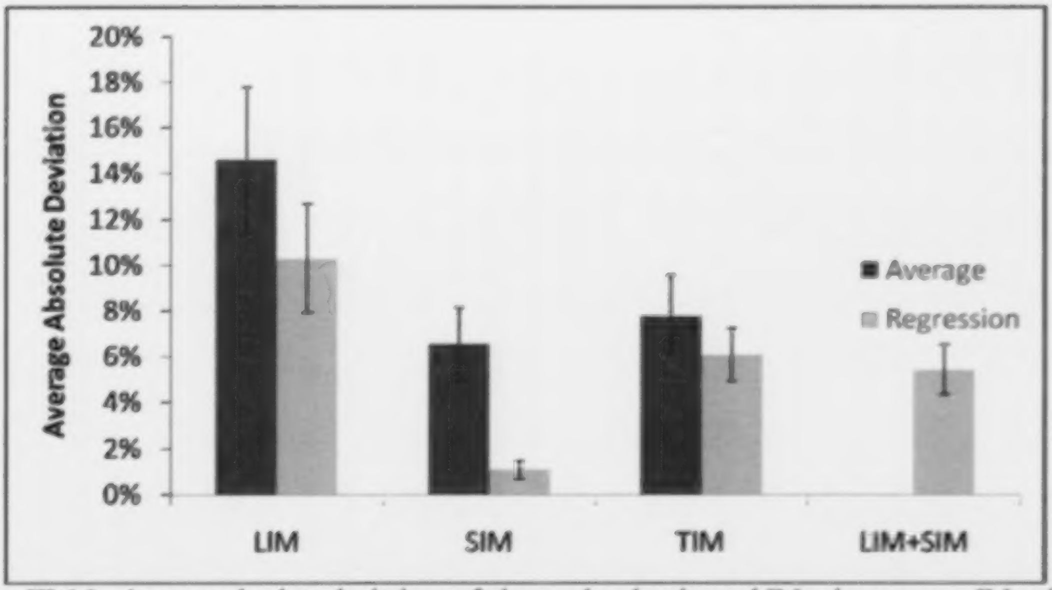

Figure III.6.3. Average absolute deviations of observed and estimated IM using average IM ratios and regression-derived IM ratios for the SEAK sport fishery, 1999-2008.

The jackknife procedure provided predictions of IM for each year using average values and regression equations generated excluding the year predicted. For TIM and LIM, the jackknife regression equations for IM:LC provided better predictions than did the use of IM:LC jackknife averages, while for SIM, the jackknife average for SIM:LC provided slightly better predictions than the jackknife regression (Figure III.6.4). Average absolute deviations were 7.5% for the jackknifed regression model, versus 8.9% for the average for TIM; 12.3% for the jackknife regression model, versus 16.2% for the jackknifed average for LIM; and 7.5% for the jackknifed regression model, versus 7.3% for the jackknifed average for SIM.

Based on these analyses, the regression relationships of IM with LC are as good or better than the use of the average IM:LC ratios both for predicting expected IM for the SEAK sport fishery, and for evaluating post-season IM in years for which estimates from a valid sampling program are not available. As with the troll fishery, the fact that the deviations from observed TIM are lowest when SIM and LIM regression estimates are summed (Figure III.6.1) supports the use of these component estimates, as they also provide needed information on the partitioning of TIM into SIM and LIM.

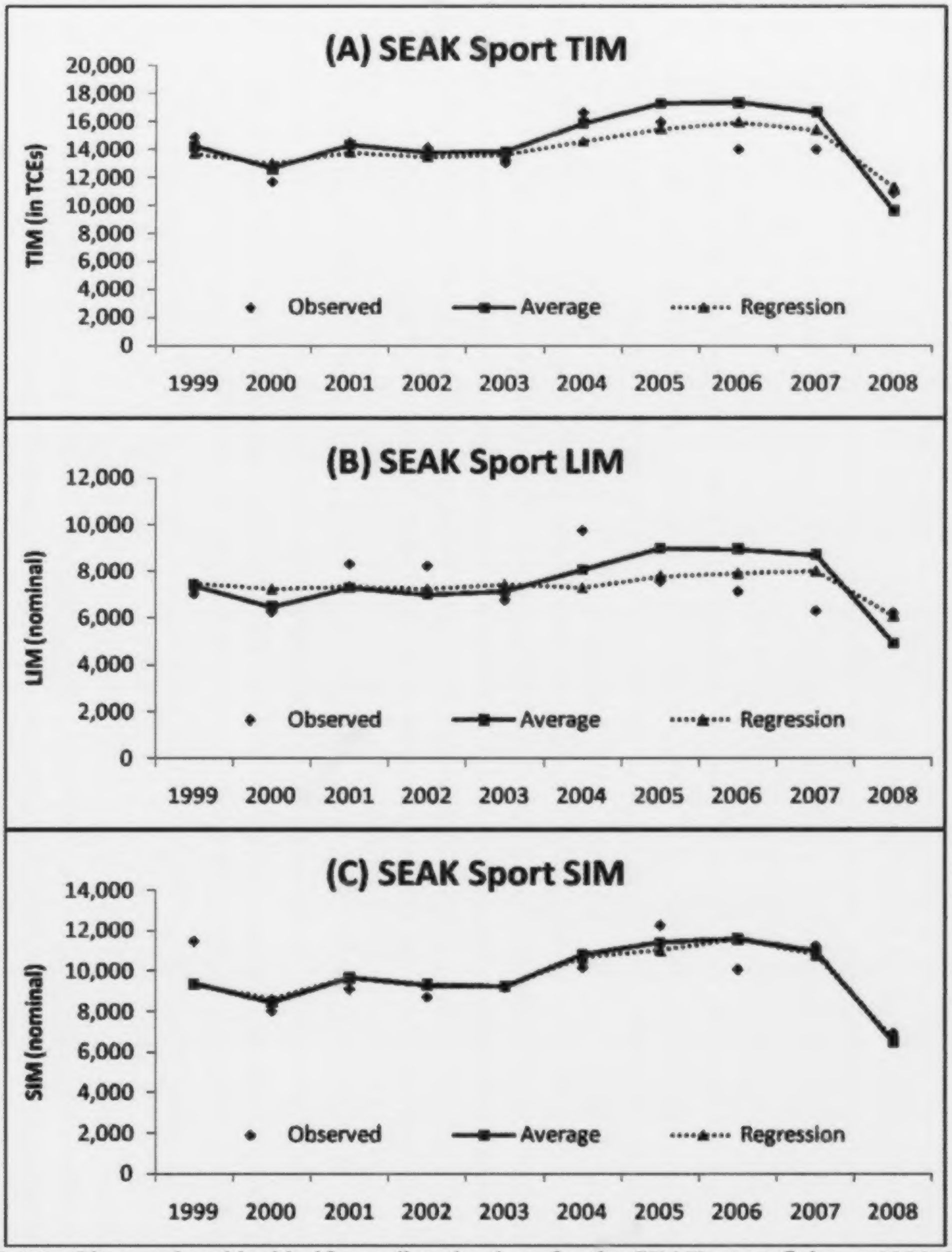

Figure III.6.4. Observed and jackknife predicted values for the SEAK sport fishery, 1999-2008 for: (A) TIM from the TIM with LC regression and TIM:LC average; B) LIM from the LIM:LC with LC regression and LIM:LC average; and (C) SIM from the SIM with LC regression and SIM:LC average.

III.6.A.3 SEAK Net Fishery

The data used for SEAK net are shown in Table III.6.7. Except for 2004 and 2005, where a logbook program was used to develop direct estimates of IM, the IM numbers in Table III.6.7 were estimated using the CPL approach described in Section II.1.A.3. The CPL approach will be used for postseason estimates of purse seine IM in future years if direct observer-based estimates are not

available. The regression and average IM:LC rate methods are compared in this section for their efficacy at predicting net IM preseason.

None of the measures of net IM were significantly correlated with LC, preseason AI, or pink salmon catch (Table III.6.8). The highest correlation was for SIM with NV:V, with $r = -0.589$. This correlation is close to statistical significance ($P = 0.069$), but it is also counter-intuitive, indicating that as the proportion of sublegal fish in a cohort decreases, the encounters of sublegals increase. The next highest correlation for SIM is with preseason AI, $r = 0.240$. For measures of LIM, the highest correlation is for LIM with LC ($r = 0.366$). For measures of TIM, the highest correlation is for TIM:LC with pink salmon harvest ($r = 0.293$). These latter three sets of parameters were used to develop regression models.

Table III.6.7. PSC Chinook Model preseason AI (PreAI), non-vulnerable (NV) AI, and ratio of non-vulnerable to vulnerable; total (treaty + non-treaty) estimates of LC, LIM, SIM and TIM, in nominal numbers, for the SEAK net fishery; and pink salmon catch in SEAK, 1999-2008.

Year	PreAI	NV_AI	NV:V	LC	LIM	SIM	TIM	Pinks (millions)
1999	1.15	0.98	0.47	32,720	1,461	7,194	7,490	77.8
2000	1.14	0.94	0.64	41,400	846	2,730	3,099	20.2
2001	1.14	1.15	0.62	40,163	1,419	6,133	6,527	67.0
2002	1.74	1.34	0.59	31,689	582	4,143	4,422	45.3
2003	1.79	1.90	0.35	39,374	723	12,674	12,979	52.5
2004	1.88	1.41	0.41	64,038	6,959	5,776	6,264	45.3
2005	2.08	1.57	0.36	71,618	1,035	7,148	8,183	59.1
2006	1.69	1.21	0.42	70,384	908	8,636	9,544	11.6
2007	1.60	1.17	0.35	55,884	6,904	33,352	33,924	44.8
2008	1.07	0.78	0.55	46,149	806	1,130	1,743	15.9
Average	1.53	1.24	0.48	49,342	2,164	8,892	9,418	44.0

Table III.6.8. Bivariate correlations (r) of LC, preseason AI (PreAI), NV_AI (post-season), NV:V, pink salmon harvest in SEAK, and measures of IM for the SEAK net fishery, 1999-2008. Numbers in bold indicate correlations greater than 0.64, which are significant at $P < 0.05$, uncorrected for multiple comparisons.

Category	LC	PreAI	NV_AI	NV:V	Pink Harvest
LC	---	0.587	–	–	-0.309
AI	0.587	---	–	–	0.088
TIM	0.262	0.266	–	–	0.144
LIM	0.366	0.259	–	–	0.095
SIM	0.196	0.240	0.200	-0.589	0.146
TIM:LC	0.017	0.159	–	–	0.293
LIM:LC	0.218	0.143	–	–	0.196
SIM:LC	-0.050	0.148	0.241	-0.528	0.294

None of the regressions were significant ($P > 0.3$; Table III.6.9). The adjusted R^2 was close to zero for all three regressions. For the LIM and SIM regressions, adding pinks as a second predictive parameter did not improve either the significance of the regression or the adjusted R^2.

Table III.6.9. Summary of parameter estimates of linear regressions of IM ratios in the SEAK net fishery. Regressions have the form: IM:LC = a + b (Predictor).

IM Ratio	Predictor	*P* regress	a	SE(a)	*P* (a)	b	SE(b)	*P* (b)	Adjusted R^2
TIM:LC	Pinks	0.411	0.089	0.115	0.461	0.002	0.002	0.411	0.028
LIM:LC	LC	0.298	-867	2836	0.768	0.061	0.055	0.298	0.000
SIM:LC	AI	0.505	-200	13.360	0.988	5,950	8,523	0.505	0.000

For both the average IM ratios and the regression models, the average absolute deviations and their standard errors were high (Figure III.6.5). There were no significant differences between the regression model average absolute deviations and the average model absolute deviations from the actual estimated IM values in Table III.6.7. The deviations were higher for the average model for SIM and TIM, and higher for the regression model for LIM.

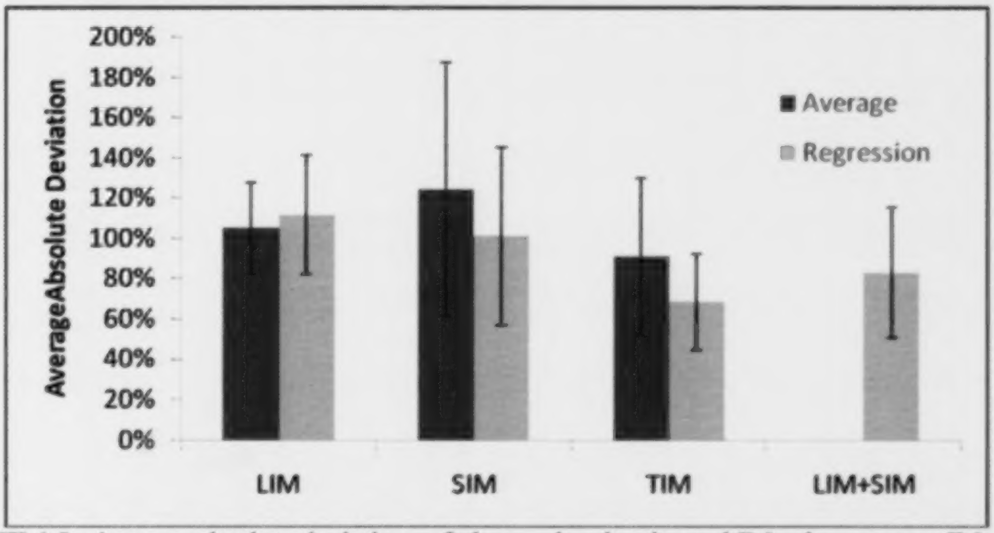

Figure III.6.5. Average absolute deviations of observed and estimated IM using average IM ratios and regression-derived IM ratios for the SEAK net fishery, 1999-2008.

The jackknife procedure provided predictions of IM for each year using average values and regression equations generated excluding the year predicted. None of the models predicted hindcast estimates that fit the observed values particularly well (Figure III.6.6). Average absolute deviations were 87% for the jackknifed regression model, versus 117% for the average for TIM; 149% for the jackknife regression model, versus 117% for the jackknifed average for LIM; and 132% for the jackknifed regression model, versus 138% for the jackknifed average for SIM.

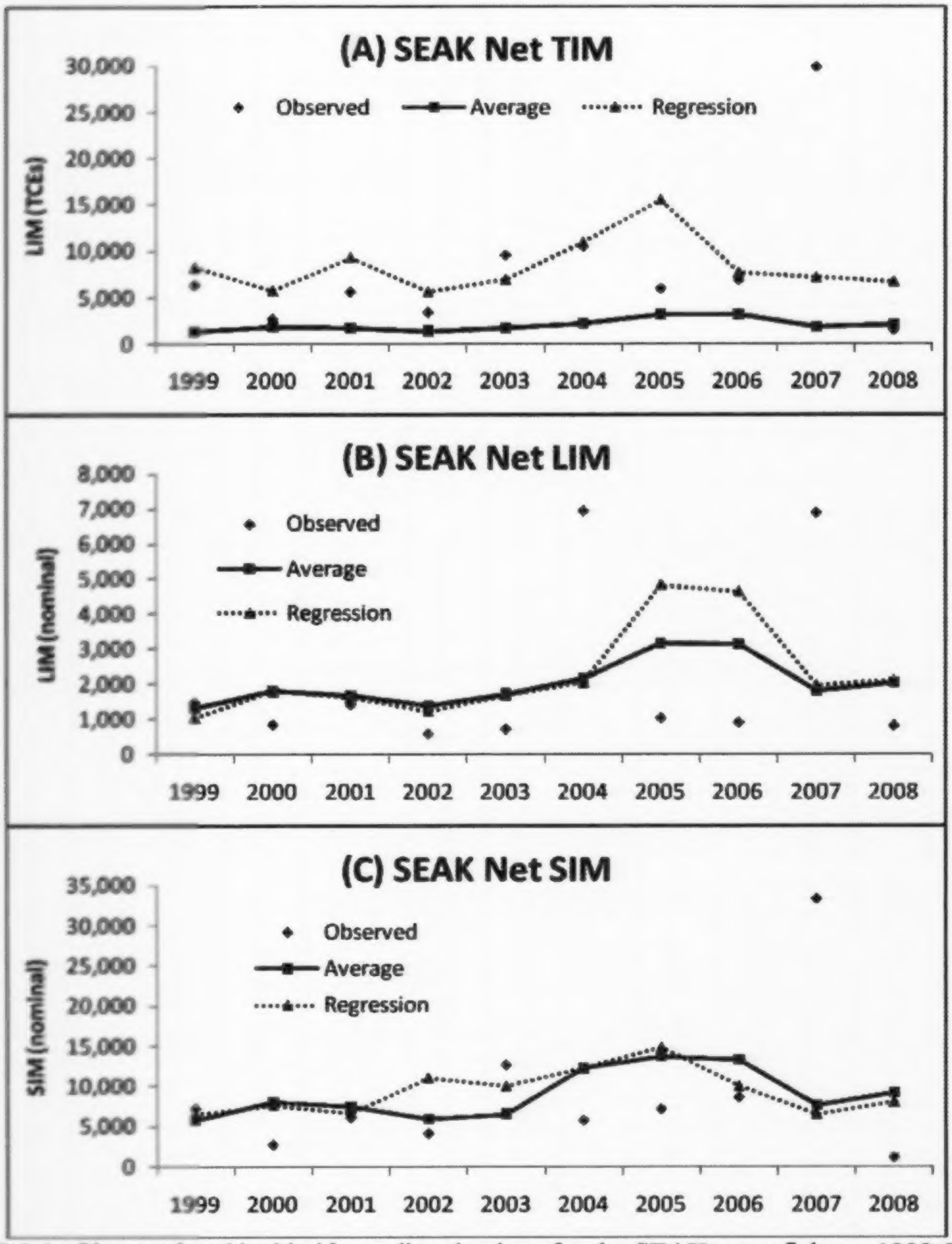

Figure III.6.6. Observed and jackknife predicted values for the SEAK sport fishery, 1999-2008 for: (A) TIM from the TIM:LC with Pinks regression and TIM:LC average; B) LIM from the LIM:LC with LC regression and LIM:LC average; and (C) SIM from the SIM with AI regression and SIM:LC average.

Based on these analyses, the regression relationships of LC and IM did not provide substantially or consistently better predictions of IM than did the average IM:LC ratios over the 1999 to 2008 time period. Until other, better predictive models are developed, the IM:LC ratios are recommended for forecasting IM in the SEAK net fishery. It should be noted that, because the average TIM is less

than 10,000 nominal fish (Table III.6.7), the high average relative errors in the predictive models for SEAK net are not large in relation to the total SEAK AABM fishery.

III.6.B NBC and WCVI AABM Fisheries

III.6.B.1 Methods for NBC and WCVI

Two approaches were for predicting IM in NBC and WCVI fisheries were compared. One approach was to use the average ratio of IM to LC from 1999-2008 to generate preseason estimates of incidental mortality based on the preseason allowable catch (PAC) corresponding to a model-based preseason abundance index (Pre AI). As an alternative approach, correlations and linear regressions of untransformed data are herein used to explore model-based variables Pre AI, a weighted preseason AI (WAI; see below), PAC, the number non vulnerable to fishing (NNV), and the number non vulnerable to vulnerable ratio (NNV:NV) as predictors of incidental mortality. In the WCVI and NBC fisheries, Chinook mortalities include both LC and IM of legal- and sublegal-sized Chinook in troll and sport sectors. Therefore, twelve metrics of IM were included in the analyses: LIM from troll, sport, and pooled troll and sport (LIM_{Troll}, LIM_{Sport}, and LIM_{T+S}, respectively), SIM from troll, sport, and pooled (SIM_{Troll}, SIM_{Sport}, and SIM_{T+S}, respectively), total (i.e., legal and sublegal) incidental mortality from troll, sport, and pooled (TIM_{Troll}, TIM_{Sport}, and TIM_{T+S}, respectively), and the mortality ratios LIM_{T+S}:LC, SIM_{T+S}:LC, and TIM_{T+S}:LC. In addition, the relationship between LC and the IM metrics above was also examined. If a significant predictive relationship between IM and LC is found, then the preseason allowable catch (PAC) could be used as a surrogate of LC to predict IM. Because the number nonvulnerable is only relevant to sublegal fish, NNV and NNV:NV were only explored as predictors for SIM_{Troll}, SIM_{Sport}, and SIM_{T+S}.

Preliminary analyses showed that the efficiency of preseason AI to predict total incidental mortality or the mortality ratio TIM:LC can be improved in some cases by weighing Pre AI by the bias correction factor of the previous year (equation 1; subscripts *i* and *f* represent year and fishery, respectively). Thus, the predictive efficiency of WAI was also explored in the present analysis.

$$WAI_{i,f} = (\text{Pre AI})_{i,f} * (\text{Post AI} / \text{Pre AI})_{i-1,f} \qquad \text{(Equation III.6.1)}$$

Updated (May 2010) data for catch and incidental mortality in troll and sport fisheries in Canadian AABM fisheries were used for this analysis. Table III.6.10 shows the data used for the present evaluation. Methods described in Section III.4.B were used to adjust incidental mortality values from troll fisheries. PAC, LC, and AI data were extracted from CTC 2009a, CTC 2009b and the most recent PSC Chinook Model calibration (1007). Correlation and regression analyses used data for 1999-2008, evaluation of predictor's performance used data from year 2009, and data from year 2010 were used in a forecasting exercise. Hindcasting was used to compare observed TIM with that derived from the period's average TIM:LC ($\overline{TIM/LC}$; equation III.6.2) and that derived from linear regressions. Jackknifed average and regressions were used for hindcasting by omitting the data corresponding to the hindcasted year.

$$TIM_{i,f} = \overline{TIM/LC}_f * LC_{i,f} \qquad \text{(Equation III.6.2)}$$

PAC was used as surrogate of LC for forecasting purposes either using the average mortality ratio equation 3) or LC as predictor.

$$TIM_{i,f} = \overline{TIM/LC}_f * PAC_{i,f} \qquad \text{(Equation III.6.3)}$$

III.6.B.2 Results for NBC and WCVI

Strong correlates of LIM_{Troll}, SIM_{Troll}, TIM_{Troll}, and LIM_{Sport} were found in NBC. While WAI was the best correlate of LIM_{Troll} and LIM_{Sport}, NNV:NV was the best correlate of SIM_{Troll}, and observed landed catch (LC) was the best correlate of TIM_{Troll} (Table III.6.11). Since SIM_{Sport} is assumed to be zero in NBC, TIM_{Sport} is equivalent to LIM_{Sport} and SIM_{T+S} is equivalent to SIM_{Troll}. The existence of strong correlates for LIM_{T+S}, TIM_{T+S}, and SIM_{T+S}:LC in NBC becomes of secondary importance in the presence of more direct ways of predicting gear- and size-specific IM.

Strong correlates of LIM_{Troll}, LIM_{Sport}, and SIM_{Sport} were found in WCVI. While Pre AI was the best correlate of LIM_{Troll} and SIM_{Sport}, landed catch (LC) was the best correlate of LIM_{Sport}. Interestingly, negative relationships exist between SIM_{Sport} and all correlates indicating abundance or catch (Table III.6.12). Since a strong correlate of SIM_{Troll} is lacking, and given the strong correlation between SIM_{T+S} and LC, LC as a predictor of SIM_{T+S} could be used in combination with SIM_{Sport} to predict SIM_{Troll}. As in NBC, the existence of strong correlates for SIM_{T+S}:LC and TIM_{T+S}:LC in WCVI becomes of secondary importance given the presence of more direct ways of predicting gear- and size-specific IM.

The exploratory correlation analysis supported the feasibility of predicting IM at the gear- and size-specific levels in both Canadian AABM fisheries. Linear-regression models for the strongest correlates are shown in Table III.6.13, with WAI and NNV:NV as the best predictors of incidental mortality in NBC, and Pre AI and LC as the best predictors in WCVI. In NBC, WAI explained 79% of the variation in LIM_{Troll} and 75% of the variation in LIM_{Sport}, while NNV:NV explained 53% of the variation in SIM_{troll}. In WCVI, Pre AI explained 60% of the variation in LIM_{Troll} and 73% of the variation in SIM_{Sport}, while LC explained 54% of the variation in LIM_{Sport} and 38% of the variation in SIM_{T+S}.

Because the use of LC as a predictor of IM requires the use of PAC as surrogate of LC for preseason purposes, it is important that LC does not deviate substantially from PAC. LC for WCVI has been above the PAC in three of the 11 years of the time series (Figure III.6.7), with allowable and observed catch strongly correlated ($r = 0.78$). In NBC, LC has been lower than the PAC for the entire time period, thus indicating potential over forecasting of incidental mortality if LC were used as predictor. LC and PAC were also strongly correlated ($r = 0.96$) in NBC.

Hindcasting of TIM estimated from the jackknifed average mortality ratio $\overline{TIM/LC}$ and TIM estimated as the sum of incidental mortality components (LIM_{Troll}, SIM_{Troll}, and LIM_{Sport} in NBC and LIM_{Troll}, LIM_{Sport}, and SIM_{T+S} in WCVI) from regressions using the best predictors (WAI and NNN:NV for NBC and Pre AI and LC for WCVI) showed that predictors outperformed the average $\overline{TIM/LC}$ (Figure III.6.8) by generating smaller deviations. Average absolute deviations from observed TIM across the time series was 24.5% for the jackknifed regressions and 39.1% for $\overline{TIM/LC}$ in NBC (Table III.6.14). Similarly, average absolute deviations in WCVI were 11.1% and

20.9% for regressions and $\overline{TIM/LC}$, respectively. Although SIM_{Sport} was not used to hindcast TIM_{T+S} in WCVI, its computation would become useful for forecasting purposes, where SIM_{Troll} would be the difference between SIM_{T+S} and SIM_{Sport}.

III.6.B.3 Forecasting TIM for NBC and WCVI

Using the linear-regression models in Table III.6.13, gear- and size-specific IM values were computed for years 2009 and 2010 based on predictor' values for these years in NBC and WCVI (see Table III.6.10). Predictive efficiency of regression models and the average mortality ratio $\overline{TIM/LC}$ were evaluated by comparing their corresponding TIM_{T+S} estimates with the TIM_{T+S} observed in year 2009 in both AABM fisheries. The TIM_{T+S} computed from regression models was closer to the 2009 observed values than the TIM_{T+S} derived from $\overline{TIM/LC}$ (Table III.6.15). Deviations from the regression models were 52% for NBC and 14% in WCVI, whereas those corresponding to average $\overline{TIM/LC}$ were 143% for NBC and 17% for WCVI. In terms of 2010 forecasts, regression models predict a total incidental mortality of 12,393 in NBC and 14,400 in WCVI, whereas 19,925 in NBC and 13,077 in WCVI are predicted from the average mortality ratio $\overline{TIM/LC}$.

III.6.B.4 Conclusions for NBC and WCVI

For both the NBC and WCVI AABM fisheries, the following conclusions can be drawn:

1. The use of linear regressions for individual components of IM allowed not only the prediction of gear- and size-specific IM but also improved the overall prediction of TIM_{T+S} relative to the use of the average mortality ratio $\overline{TIM/LC}$ in both Canadian AABM fisheries.

2. The weighted preseason AI (WAI) was a stronger correlate than the preseason AI for several IM metrics in NBC and WCVI.

3. Although coefficients of determination of predictive models of IM components were lower in WCVI than in NBC, prediction error for total incidental mortality (TIM_{T+S}) was greater in NBC than in WCVI.

4. The efficiency of predictors is expected to become more apparent as data from future years are incorporated. It is important to bear in mind that the use of LC as predictor (e.g., in WCVI) would depend strongly on the ability of harvesting at PAC levels. Thus, management error or management decisions relative to allowable catches should be considered. If strong deviations from PAC are anticipated, other predictors should be used to estimate IM components.

Table III.6.10. Preseason and postseason AIs, weighted abundance index (WAI), number vulnerable (NV), number non vulnerable (NNV), number non vulnerable to vulnerable ratio (NNV:NV), treaty catch (preseason allowable catch [PAC] and observed LC), and observed LIM, SIM, and TIM from troll, sport, and pooled troll and sport ("T+S" subscript) for Canadian AABM fisheries. IM from troll fisheries has been adjusted according to methods in section III.4.B. Averages represent the period 1999-2008.

								Treaty	Catch									
Fishery	Year	Pre AI	Post AI	WAI	NNV	NV	NNV:NV	PAC	Observed	LIM Troll	SIM Troll	TIM Troll	LIM Sport	SIM Sport	TIM Sport	LIM T+S	SIM T+S	TIM T+S
WCVI	1999	0.60	0.50		128,909	153,473	0.84	128,300	36,400	90	721	811	2,146			2,236		
	2000	0.54	0.47	0.450	129,364	155,692	0.83	115,500	101,400	1,608	4,220	5,828	2,626	3,629	6,255	4,234	7,849	12,083
	2001	0.66	0.68	0.574	235,950	240,960	0.98	141,200	117,700	2,491	6,078	8,569	4,397	3,271	7,668	6,888	9,349	16,237
	2002	0.95	0.92	0.979	349,455	351,502	0.99	203,200	165,000	3,583	4,763	8,346	4,540	1,441	5,981	8,123	6,204	14,327
	2003	0.85	1.10	0.823	259,103	370,169	0.70	181,800	175,800	2,986	5,520	8,506	6,297	1,216	7,513	9,283	6,736	16,019
	2004	0.90	0.98	1.165	248,230	304,895	0.81	192,500	216,600	3,177	3,501	6,678	5,781	1,053	6,834	8,958	4,554	13,512
	2005	0.88	0.84	0.958	173,872	246,030	0.71	188,200	202,700	2,582	3,349	5,931	7,207	878	8,085	9,789	4,227	14,016
	2006	0.75	0.68	0.716	147,978	193,011	0.77	160,400	146,900	2,603	3,147	5,750	4,800	1,161	5,961	7,403	4,308	11,711
	2007	0.67	0.57	0.607	109,043	164,900	0.66	143,300	139,200	1,580	3,259	4,839	4,343	2,993	7,336	5,923	6,252	12,175
	2008	0.76	0.64	0.647	195,892	198,712	0.99	162,600	143,800	1,578	2,367	3,945	6,269	1,549	7,818	7,847	3,916	11,763
	2009	0.72	0.61	0.606	152,770	223,556	0.68	107,800	124,600									
	2010	0.96		0.813	150,853	185,273	0.81	143,700										
	Average	0.76	0.74	0.77	197,780	237,934	0.83	161,700	144,550	2,228	3,693	5,920	4,841	1,910	7,050	7,068	5,933	13,538
NBC	1999	1.12	0.97		74,380	117,603	0.63	145,600	86,700	1,430	4,973	6,403	5,124	0	5,124	6,554	4,973	11,527
	2000	1.00	0.95	0.866	100,104	115,578	0.87	130,000	31,900	276	318	594	6,243	0	6,243	6,519	318	6,837
	2001	1.02	1.22	0.969	131,458	149,405	0.88	132,600	43,500	362	501	863	7,958	0	7,958	8,320	501	8,821
	2002	1.45	1.63	1.734	183,582	209,200	0.88	192,700	150,100	3,102	893	3,995	11,357	0	11,357	14,459	893	15,352
	2003	1.48	1.90	1.664	147,418	235,547	0.63	197,100	191,700	5,462	726	6,188	12,876	0	12,876	18,338	726	19,064
	2004	1.67	1.83	2.144	147,340	222,672	0.66	243,600	241,500	10,649	2,603	13,252	27,520	0	27,520	38,169	2,603	40,772
	2005	1.69	1.65	1.852	112,059	190,784	0.59	246,600	243,600	6,276	5,069	11,345	16,457	0	16,457	22,733	5,069	27,802
	2006	1.53	1.50	1.494	90,887	153,359	0.59	223,200	216,000	3,310	2,759	6,069	10,687	0	10,687	13,997	2,759	16,756
	2007	1.35	1.10	1.324	69,768	121,255	0.58	178,000	144,200	2,352	3,423	5,775	11,030	0	11,030	13,382	3,423	16,805
	2008	0.96	0.93	0.782	92,651	115,089	0.81	124,800	95,600	1,305	1,413	2,718	5,046	0	5,046	6,351	1,413	7,764
	2009	1.10	1.07	1.066	85,679	135,578	0.63	143,800	109,500									
	2010	1.17		1.138	89,939	126,050	0.71	152,100										
	Average	1.33	1.37	1.43	114,965	163,049	0.71	181,420	144,480	3,452	2,268	5,720	11,430	0	11,430	14,882	2,268	17,150

*** Sublegal incidental mortality associated with sport fisheries in WCVI was not evaluated in 1999. Consequently, year 1999 was removed from some of the analyses.

Table III.6.11. Pearson correlation coefficients (r) between potential predictors of IM and twelve mortality metrics in NBC (see text for details). Since SIM_{Sport} is assumed to be zero, TIM_{Sport} is equivalent to LIM_{Sport} and SIM_{T+S} is equivalent to SIM_{Troll}. Shaded values indicate the strongest correlate for each of the incidental mortality metrics.

	Incidental mortality metric											
	Troll			Sport			Troll plus Sport					
Predictor	LIM	SIM	TIM	LIM	SIM	TIM	LIM	SIM	TIM	LIM:LC	SIM:LC	TIM:LC
Pre AI	0.839	0.6523	0.8865	0.7986	-	-	0.8186	-	0.851	-0.3662	0.0546	-0.368
WAI	0.9022	0.4933	0.8762	0.8853	-	-	0.8982	-	0.9007	-0.2159	-0.1062	-0.2349
PAC	0.8493	0.6924	0.9093	0.8121	-	-	0.8311	-	0.8685	-0.3434	0.0944	-0.3392
LC	0.8516	0.6998	0.9138	0.7594	-	-	0.7964	-	0.8376	-0.5357	0.1157	-0.5334
NNV	-	-0.3796	-	-	-	-	-	-	-	-	-0.7415	-
NNV:NV	-	-0.769	-	-	-	-	-	-	-	-	-0.4619	-

Table III.6.12. Pearson correlation coefficients between potential predictors of IM and the twelve mortality metrics in WCVI (see text for details). Shaded values indicate the strongest correlate for each of the IM metrics.

	Incidental mortality metric											
	Troll			Sport			Troll plus Sport					
Predictor	LIM	SIM	TIM	LIM	SIM	TIM	LIM	SIM	TIM	LIM:LC	SIM:LC	TIM:LC
Pre AI	0.8059	-0.0383	0.3281	0.6966	-0.8722	0.0352	0.8905	-0.5272	0.3283	0.0309	-0.7641	-0.6972
WAI	0.7941	-0.0844	0.2894	0.6045	-0.7998	-0.0257	0.8127	-0.5156	0.2631	-0.2359	-0.7298	-0.7349
PAC	0.8058	-0.0382	0.3282	0.6967	-0.8721	0.0354	0.8905	-0.5271	0.3284	0.0313	-0.764	-0.697
LC	0.6272	-0.2056	0.1273	0.7738	-0.8425	0.2046	0.876	-0.6196	0.2161	-0.2348	-0.8195	-0.8192
NNV	-	0.5061	-	-	-0.3948	-	-	0.1041	-	-	-0.1463	-
NNV:NV	-	0.1962	-	-	0.1484	-	-	0.2139	-	-	0.2713	-

Table III.6.13. Summary of parameter estimates of linear regressions between predictors and metrics of IM for Canadian AABM fisheries, NBC and WCVI. Regressions have the form: IM = a + b (Predictor).

Fishery	Predictor	IM metric	a	SE(a)	P(a)	b	SE(b)	P(b)	Adj. R^2
NBC	WAI	LIM Troll	-5361.41	1712.02	0.0166	6340.85	1145.95	0.0009	0.79
NBC	NNV:NV	SIM Troll	8543.47	2098.38	0.0047	-9145.67	2873.53	0.0154	0.53
NBC	WAI	LIM Sport	-5769.39	3723.89	0.1652	12557.37	2492.03	0.0015	0.75
WCVI	Pre AI	LIM Troll	-975.78	968.29	0.3471	4449.72	1235.77	0.0087	0.60
WCVI	LC	LIM Sport	682.28	1414.18	0.6442	0.0285	0.0088	0.0144	0.54
WCVI	Pre AI	SIM Sport	7308.67	1159.23	0.0004	-6980.89	1479.45	0.0022	0.73
WCVI	LC	SIM T+S	10737.3	2358.52	0.0026	-0.0307	0.0147	0.0751	0.38

Table III.6.14. Absolute difference (number of fish) and absolute deviations (percent error) between observed and hindcasted TIMT+S (for the purposes of this table, TIM = TIM_{T+S}) in Canadian AABM fisheries. TIM was hindcasted from the jackknifed time series average TIM:LC ratio and the jackknifed linear regressions between components of IM and best predictors shown in Table III.6.13.

AABM Fishery	Year	Average TIM:LC		IM regressions	
		Absolute Difference (#)	Absolute Deviations (%)	Absolute Difference (#)	Absolute Deviations (%)
NBC	2000	2,997	43.84%	1,385	20.26%
	2001	3,525	39.96%	1,479	16.77%
	2002	4,818	31.38%	8,064	52.53%
	2003	6,768	35.50%	4,831	25.34%
	2004	10,343	25.37%	14,713	36.09%
	2005	4,566	16.42%	1,023	3.68%
	2006	12,917	77.09%	3,972	23.70%
	2007	2,302	13.70%	386	2.30%
	2008	5,333	68.69%	3,093	39.84%
	Sum	53,569		38,946	
	Average		39.11%		24.50%
WCVI	2000	3,261	26.99%	806	6.67%
	2001	6,277	38.66%	4,090	25.19%
	2002	688	4.80%	143	1.00%
	2003	109	0.68%	2,552	15.93%
	2004	6,875	50.88%	871	6.45%
	2005	4,886	34.86%	220	1.57%
	2006	1,785	15.24%	1,983	16.93%
	2007	492	4.04%	1,122	9.22%
	2008	1,413	12.01%	1,980	16.83%
	Sum	2,5786		13,767	
	Average		20.91%		11.09%

Table III.6.15. Canadian AABM IM components predicted from regressions, WCVI SIM_{Troll} calculated as the difference between SIM_{T+S} and SIM_{Sport}, and TIM_{T+S} derived from regressions and the time series average TIM:LC ratio. For comparison, the TIM_{T+S} observed in year 2009 is shown in the last column. Regressions and average TIM:LC were computed from 1999-2008 data.

		Predicted from regressions					Calculated	TIM_{T+S}		
AABM	Year	LIM_{Troll}	SIM_{Troll}	LIM_{Sport}	SIM_{T+S}	SIM_{Sport}	SIM_{Troll}	Regression	Average TIM:LC	Observed
NBC	2009	1,398	2,764	7,617				11,779	18,838	7,764
NBC	2010	1,854	2,018	8,521				12,393	19,925	
WCVI	2009	2,228		3,755	7,428	2,282	5,146	13,411	9,810	11,763
WCVI	2010	3,296		4,778	6,326	607	5,719	14,400	13,077	

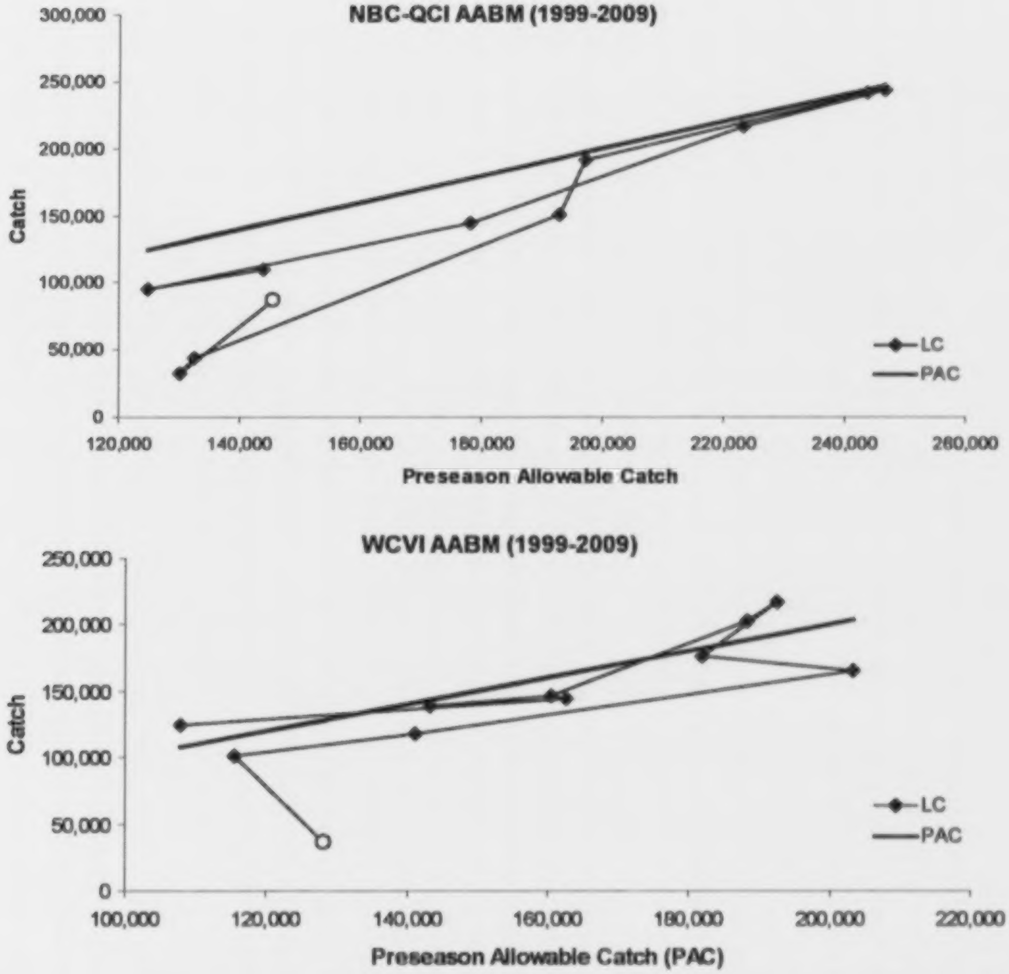

Figure III.6.7. Relationship between preseason allowable catch (PAC) and LC in Canadian AABM fisheries. The points represent predicted vs. observed catch for the period 1999-2009; the open circle indicates the beginning of the time series (i.e., 1999). The solid line represents the 1:1 PAC relationship.

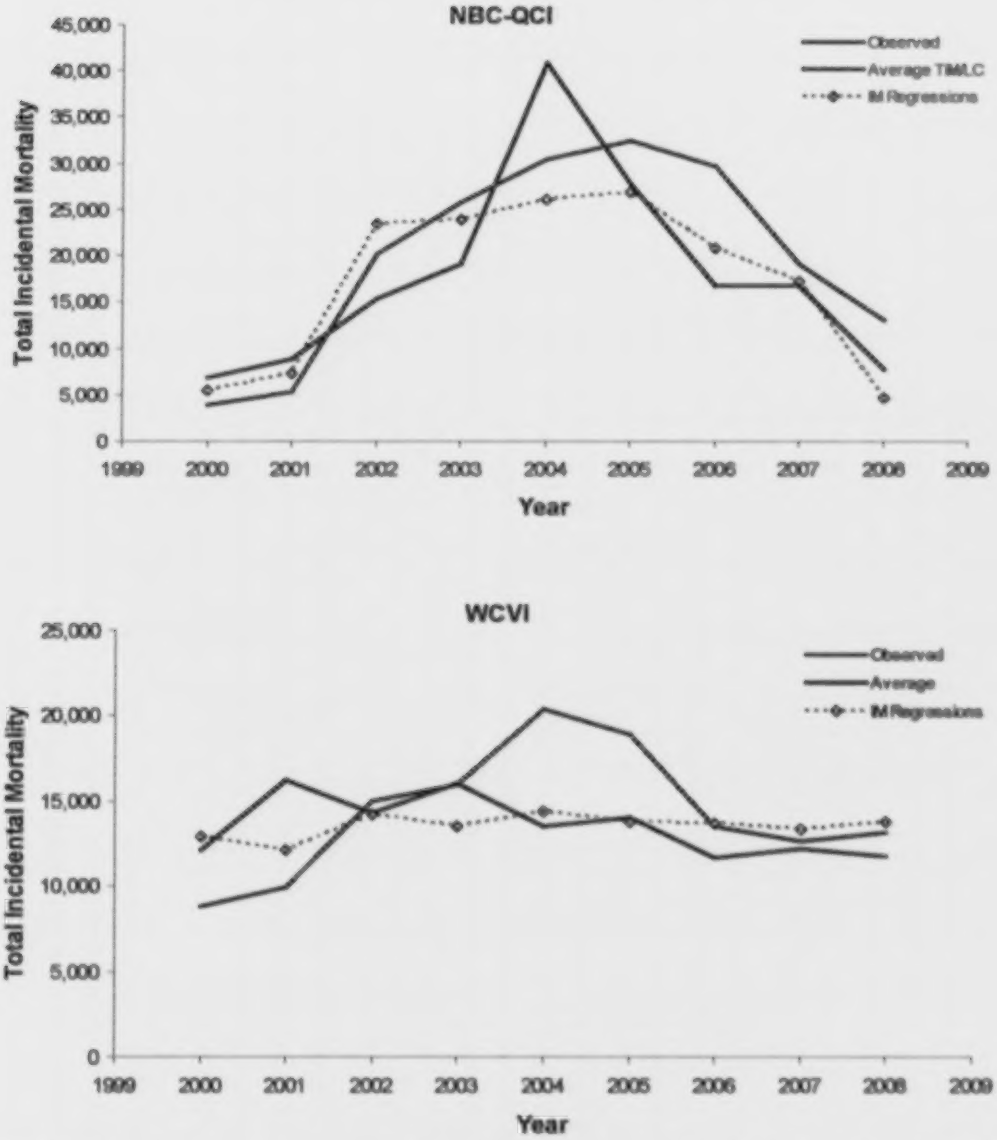

Figure III.6.8. Time series of observed and hindcasted estimates of TIM in Canadian AABM fisheries. Observed TIM is compared with estimates generated from jackknifed linear regressions and jackknifed 1999-2008 average TIM:LC ratio.

III.7 VARIABILITY IN AEQS BY FISHERY AND GEAR

The AEQ values from the PSC Chinook Model are used to calculate the scalars for computing LCEs both within gear types and between gear types. Average AEQ values for the 1985-1995 IM base period were used to calculate LCEs for developing the TM Table 1 (Section II). Similarly, average AEQ values for 1999-2008 were used in Section IV below to evaluate the effect of temporal changes in IM ratios on LC and TM. However, annual variation in average AEQ values

for a gear and fishery could affect the scalars used to estimate TM in terms of LCEs in the implementation of a TM regime. This section examines the variability in AEQs over the two time periods, and the effect of the annual variation on the LCE scalars.

III.7.A Variation in Average AEQs

The coefficient of variation (CV) for the average AEQs used in Section II and IV were generally low (Table III.7.1). For legal-sized fish, CVs for the average AEQs were 2.5% or less. For sublegal-sized fish, CVs were 3.4% or less. The NBC troll (legal and sublegal) and SEAK net sublegal AEQ values were not evaluated, as these values are not used in the calculation of LCE scalars (Section II).

Average AEQ values for each gear type within an AABM fishery were generally very similar between the 1985-1995 base period and the 1999-2008 period for both legal- and sublegal-sized fish, with the exception of sublegal-sized fish in the WCVI fishery. The average AEQs for SEAK troll (legal and sublegal), SEAK sport (legal and sublegal), SEAK net (legal), NBC troll (legal and sublegal), WCVI sport (legal and sublegal), and WCVI troll (legal) differed by less than 1% between the two time periods, and were not significantly different (two-sample t-test, $P > 0.1$). In contrast, WCVI troll sublegal average AEQ was 15% lower in the 1999-2008 period, which was a significant ($P < 0.001$) decline. This decline is attributed primarily to imposition of a lower minimum size in the recent period. See Section V.4 for more discussion of the effects of size limit changes.

Table III.7.1. Average, standard deviation (SD), and coefficient of variation (CV) for average AEQs for legal- and sublegal-sized Chinook in AABM fisheries by gear type for 1985-1995 and 1999-2008. AEQ values are derived from PSC Chinook Model calibration 0907.

			Legal Average AEQs			Sublegal Average AEQs		
Fishery	Gear	Period	Average	SD	CV	Average	SD	CV
SEAK	Troll	1985-1995	0.928	0.008	0.9%	0.684	0.016	2.3%
		1999-2008	0.930	0.010	1.1%	0.680	0.016	2.3%
	Sport	1985-1995	0.899	0.007	0.8%	0.657	0.015	2.2%
		1999-2008	0.901	0.010	0.9%	0.653	0.014	2.1%
	Net	1985-1995	0.863	0.022	2.5%	NA		
		1999-2008	0.864	0.014	1.7%	NA		
NBC	Troll	1985-1995	0.891	0.015	1.7%	0.685	0.022	3.2%
		1999-2008	0.893	0.013	1.5%	0.689	0.017	2.5%
	Sport	1985-1995	NA			NA		
		1999-2008	NA			NA		
WCVI	Troll	1985-1995	0.904	0.014	1.6%	0.695	0.023	0.8%
		1999-2008	0.895	0.013	1.4%	0.597	0.005	0.8%
	Sport	1985-1995	0.895	0.013	1.5%	0.590	0.005	3.4%
		1999-2008	0.899	0.012	1.3%	0.588	0.005	0.8%

III.7.B Annual Variation in LCE Scalars

III.7.B.1 LCE Scalars

The annual variation in the ratio of average AEQ values for sublegal:legal fish, used to calculate LCEs within gear types, was examined for the recent (1999-2008) period for SEAK troll and sport;

NBC troll; and WCVI troll and sport. SEAK net and NBC sport were not evaluated, because sublegal AEQ values used for LCE scalars for these fishery by gear strata are derived from other strata (Section II.2). Figure III.7.1 and Figure III.7.3 show the ratio values computed annually in relation to the average values for the period. For the SEAK troll fishery, the absolute deviation averaged 1.9%, and ranged annually from 0.2%-5.2%. For the SEAK sport fishery, the absolute deviation averaged 1.7%, and ranged annually from 0%-4.4%. For the NBC troll fishery, the absolute deviation averaged 1.8%, and ranged annually from 0.7%-5.3%. For the WCVI troll fishery, the absolute deviation averaged 1.2%, and ranged annually from 0.1%-2.7%. For the WCVI sport fishery, the absolute deviation averaged 1.2%, and ranged annually from 0.6%-2.2%. While the average deviation was small, the LCE scalar for converting sublegal-sized fish did vary as much as 5% from the average value over the time period.

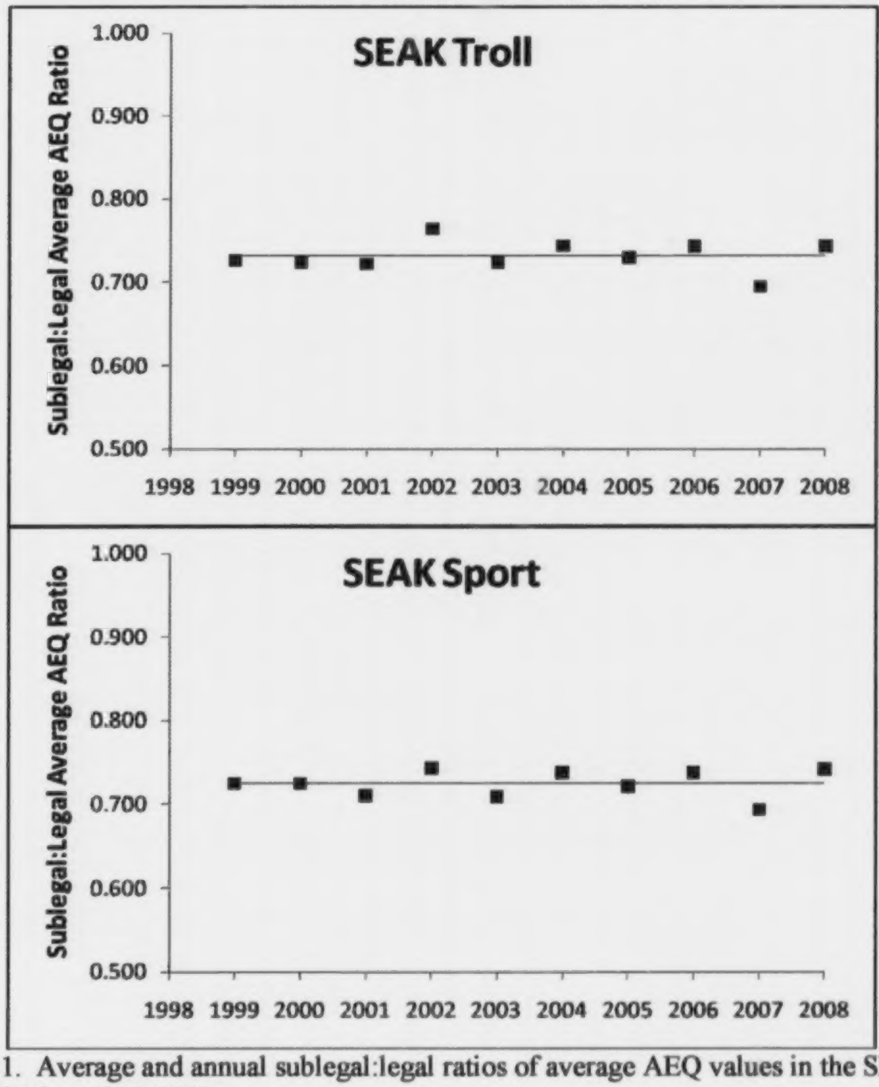

Figure III.7.1. Average and annual sublegal:legal ratios of average AEQ values in the SEAK troll and sport fisheries, 1999-2008.

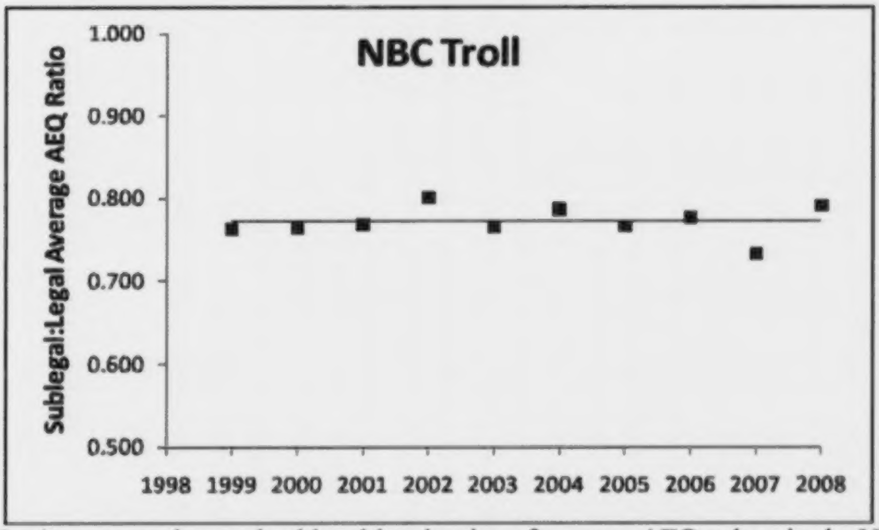

Figure III.7.2. Average and annual sublegal:legal ratios of average AEQ values in the NBC troll fishery, 1999-2008.

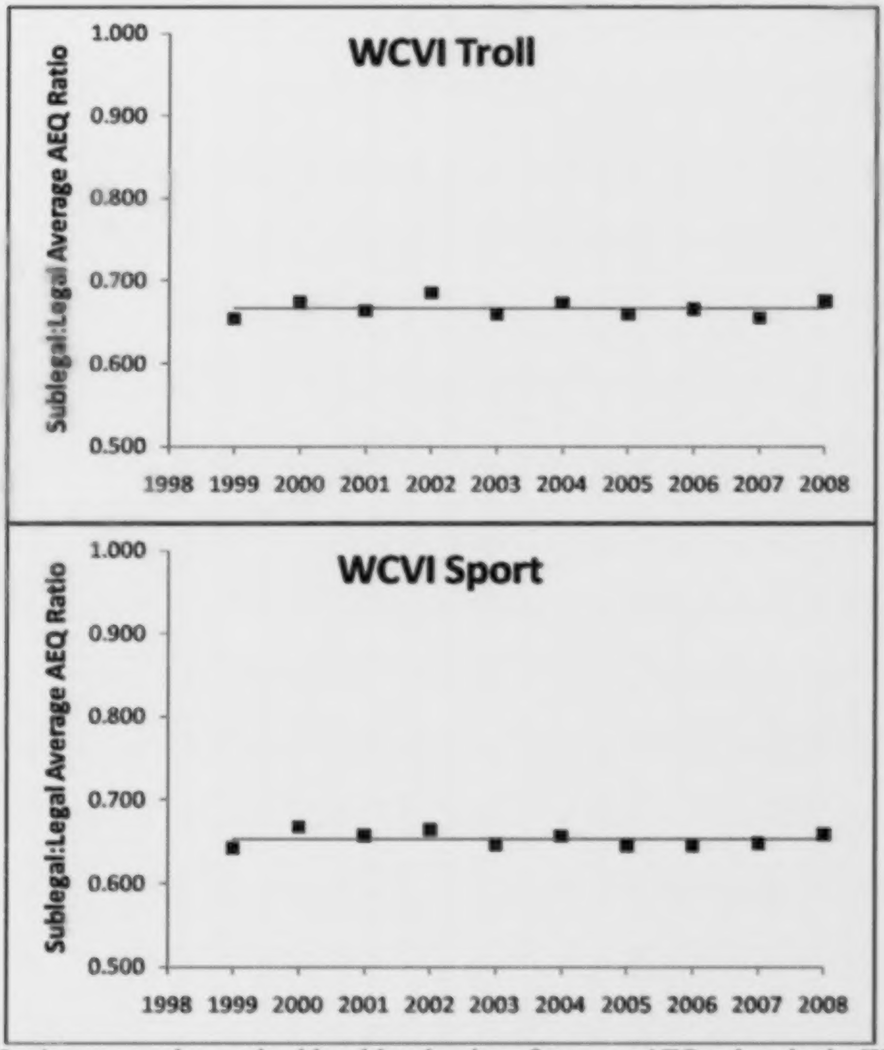

Figure III.7.3. Average and annual sublegal:legal ratios of average AEQ values in the WCVI troll and sport fisheries, 1999-2008.

III.7.B.2 TCE Scalars

The annual variation in the ratio of average AEQ values for legal-sized fish between fisheries, used to calculate TCEs for the AABM fisheries, was examined for the recent (1999-2008) period for SEAK sport and net relative to troll, and for WCVI sport relative to troll. Figure III.7.4 and Figure III.7.5 show the ratio values for TCEs for these fisheries computed annually in relation to the average values for the period. The degree of variation for the TCE scalars between gear types was generally lower than that of the LCEs for sublegal:legal AEQ ratios within gear type. For SEAK sport:troll, the absolute deviation averaged 0.7%, and ranged from 0.2%-1.6%. For SEAK net:troll, the absolute deviation averaged 0.9%, and ranged from 0.2%-2.6%. For the WCVI sport:troll, the absolute deviation averaged 0.3%, and ranged from 0 %-0.7%.

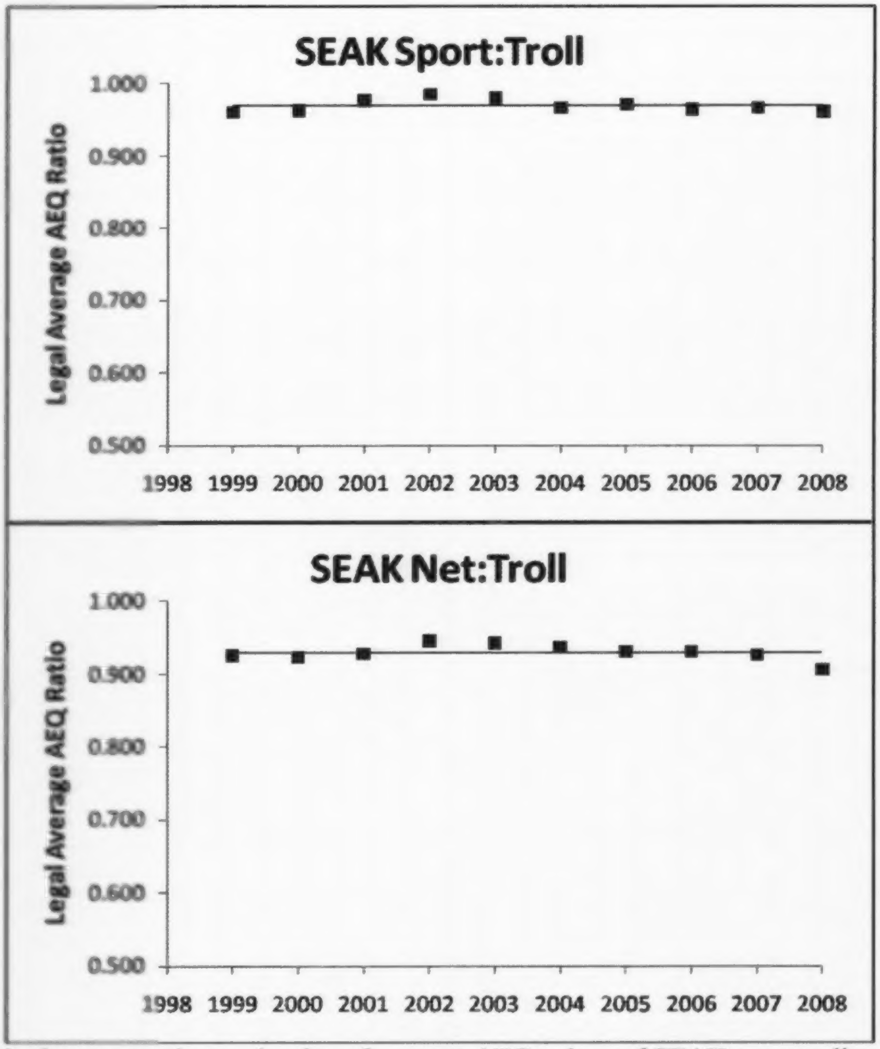

Figure III.7.4. Average and annual ratios of average AEQ values of SEAK sport:troll and net:troll, 1999-2008.

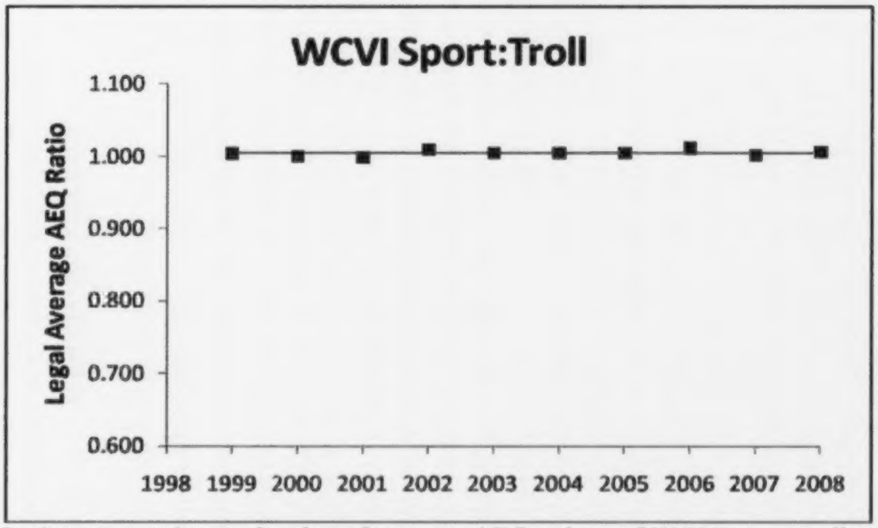

Figure III.7.5. Average and annual ratios of average AEQ values of WCVI sport:troll, 1999-2008.

III.7.C Annual Estimation of Average AEQ Values for TM Management

Although the annual variability in AEQ values is small, this variability does introduce a degree of annual variation in the LCE scalars, as shown in Sections III.7.A and III.7.B. If reliable estimates of AEQ values are available from the PSC Chinook Model calibrations, then those values could be used to construct the LCE scalars needed for both calculating TM in TCEs for post-season accounting, and estimating TM in TCEs preseason. Because cohorts are not complete for some stock by age components within a gear and fishery, AEQ values may be biased and change in subsequent calibrations. This section examines the stability of average AEQ values of legal-sized fish for the first post-season and for the preseason calibrations. For these analyses, average AEQs for legal-sized fish were compiled from 13 annual calibrations from 1998-2010 for SEAK troll, sport, and net, NBC troll, and WCVI troll and sport.

III.7.C.1 Stability of Post-Season Average AEQs

To determine the degree to which average AEQ estimates from the first post-season Model calibration change with subsequent Model calibrations, the average AEQ s of legal-sized fish in a gear and fishery strata in year Y were calculated in the calibration year Y+1 (the first post-season estimate). These average AEQs were then compared with the average AEQ calculated for year Y in the calibration year Y+3, when the cohorts contributing to the fishery in year Y are complete. This analysis was done for years 1998-2007. The analysis is truncated at 2007 because that is the last year for which Y+3 calibration estimates are available. The deviation of Y+1 from Y+3 was computed as $(AEQ_{f,g,Y+3}-AEQ_{f,g,Y+1})/ AEQ_{f,g,Y+3}$, where f = AABM fishery and g = gear type.

For the SEAK troll fishery, the average of the deviations was 0.1%, indicating little bias in the first post-season estimate relative to the subsequent calibrations (Table III.7.2). The average absolute deviation was less than 1%. The range in deviations was 0.0%-2.2%. The slope of the regression line of Y+3 on Y+1 was 0.999, which was not significantly ($P > 0.05$) different from 1 (Table III.7.3).

For the SEAK sport fishery, the average of the deviations was -0.1%, indicating little bias in the first post-season estimate relative to the subsequent calibrations (Table III.7.2). The average absolute deviation was 0.4%. The range in deviations was 0.1%-0.9%. The slope of the regression line of Y+3 on Y+1 was 1.001, which was not significantly ($P > 0.05$) different from 1 (Table III.7.3).

Table III.7.2. Average AEQs in year Y for legal-sized fish in SEAK fisheries, 1998-2007, as calculated by calibrations in year Y+1 and Y+3. Deviations (dev) are the percent differences between AEQs in Y+3 and Y+1, divided by AEQs in Y+3.

	Troll			Sport			Net		
Year	Y+1	Y+3	% dev	Y+1	Y+3	%dev	Y+1	Y+3	%dev
1998	0.929	0.928	0.1%	0.896	0.895	0.2%	0.897	0.887	1.2%
1999	0.919	0.924	-0.5%	0.886	0.888	-0.2%	0.883	0.853	3.4%
2000	0.922	0.913	0.9%	0.884	0.885	-0.1%	0.849	0.855	-0.8%
2001	0.913	0.913	0.0%	0.886	0.895	-0.9%	0.852	0.850	0.2%
2002	0.931	0.911	2.2%	0.907	0.899	0.8%	0.880	0.869	1.2%
2003	0.936	0.933	0.4%	0.915	0.914	0.1%	0.889	0.879	1.1%
2004	0.929	0.937	-0.8%	0.900	0.905	-0.6%	0.875	0.882	-0.8%
2005	0.935	0.937	-0.2%	0.913	0.910	0.4%	0.881	0.866	1.8%
2006	0.932	0.941	-0.9%	0.901	0.907	-0.6%	0.871	0.876	-0.5%
2007	0.937	0.941	-0.4%	0.907	0.908	-0.1%	0.881	0.868	1.4%
Average	0.928	0.928	0.1%	0.900	0.901	-0.1%	0.876	0.869	0.8%

Table III.7.3. Regression slopes and 95% CI for the slopes of average AEQ values for legal-sized fish calculated in the Model calibration in year Y+3, and regressed on average AEQ values calculated in the Model calibration in year Y+1. Regression lines were forced through the intercept.

Fishery	Gear	Slope	Lower 95% CI	Upper 95% CI
SEAK	Troll	0.999	0.993	1.006
	Sport	1.001	0.997	1.005
	Net	0.992	0.982	1.001
NBC	Troll	0.995	0.987	1.003
WCVI	Troll	1.002	0.993	1.011
	Sport	1.006	0.990	1.022

For the SEAK net fishery, the average of the deviations was 0.8%, indicating a small positive bias in the first post-season estimate relative to the subsequent calibrations (Table III.7.2). The average absolute deviation was 1.2%. The range in deviations was 0.8%-3.4%. The slope of the regression line of Y+3 on Y+1 was 0.991, which was not significantly ($P > 0.05$) different from 1 (Table III.7.3).

Table III.7.4. Average AEQs in year Y for legal-sized fish in NBC and WCVI fisheries, 1998-2007, as calculated by calibrations in year Y+1 and Y+3. Deviations (dev) are the percent differences between AEQs in Y+3 and Y+1, divided by AEQs in Y+3.

	NBC Troll			WCVI Troll			WCVI Sport		
Year	Y+1	Y+3	% dev	Y+1	Y+3	%dev	Y+1	Y+3	%dev
1998	0.897	0.896	0.1%	0.879	0.897	-2.0%	0.864	0.909	-4.9%
1999	0.890	0.884	0.7%	0.895	0.895	0.0%	0.869	0.902	-3.7%
2000	0.887	0.866	2.5%	0.895	0.884	1.3%	0.907	0.895	1.4%
2001	0.873	0.863	1.2%	0.883	0.877	0.6%	0.892	0.882	1.1%
2002	0.896	0.879	2.0%	0.899	0.880	2.1%	0.908	0.887	2.3%
2003	0.898	0.901	-0.2%	0.908	0.907	0.1%	0.914	0.915	-0.1%
2004	0.898	0.900	-0.3%	0.891	0.901	-1.1%	0.901	0.906	-0.5%
2005	0.898	0.893	0.5%	0.895	0.901	-0.7%	0.901	0.902	-0.1%
2006	0.898	0.910	-1.3%	0.889	0.894	-0.6%	0.898	0.904	-0.7%
2007	0.903	0.907	-0.4%	0.901	0.913	-1.3%	0.906	0.917	-1.2%
Average	0.894	0.890	0.5%	0.893	0.895	-0.2%	0.896	0.902	-0.6%

For the NBC troll fishery, the average of the deviations was 0.5%, indicating a small positive bias in the first post-season estimate relative to the subsequent calibrations (Table III.7.4). The average absolute deviation was 0.9%. The range in deviations was 0.1%-2.5%. The slope of the regression line of Y+3 on Y+1 was 0.995, which was not significantly ($P > 0.05$) different from 1 (Table III.7.3).

For the WCVI troll fishery, the average of the deviations was -0.2%, indicating a small negative bias in the first post-season estimate relative to the subsequent calibrations (Table III.7.4). The average absolute deviation was 1.0%. The range in annual deviations was 0%-2.1%. The slope of the regression line of Y+3 on Y+1 was 1.002, which was not significantly ($P > 0.05$) different from 1 (Table III.7.3).

For the WCVI sport fishery, the average of the deviations was -0.6%, indicating a small negative bias in the first post-season estimate relative to the subsequent calibrations (Table III.7.4). The average absolute deviation was 1.6%. The range in annual deviations was 0.1%-4.9%. The slope of the regression line of Y+3 on Y+1 was 1.002, which was not significantly ($P > 0.05$) different from 1 (Table III.7.3).

III.7.C.2 Stability of Preseason Average AEQs

The approach to determine the degree to which the preseason average AEQ estimates change with subsequent Model calibrations was similar to that used for the post-season assessment. The average AEQ of legal-sized fish in a gear by fishery strata for year Y and calculated in the calibration for year Y (preseason) was compared with the average AEQ calculated for year Y in the calibration in year Y+3, for years 1998-2007. The deviation of Y from Y+3 was computed as $(AEQ_{f,g,Y+3} - AEQ_{f,g,Y}) / AEQ_{f,g,Y+3}$, where f = AABM fishery and g = gear type. The annual deviations were plotted and averaged; the absolute values of the deviations were also averaged. The $AEQ_{f,g,Y+3}$ was regressed on $AEQ_{f,g,Y}$, with the intercept of the regression line set to zero. A slope of 1 indicates perfect correspondence between Y and Y+3; a slope significantly different from 1 indicates bias.

For the SEAK troll fishery, the average of the deviations was 0.3%, indicating slight positive bias in the preseason estimate relative to the subsequent calibrations (Table III.7.5). The average absolute

deviation was less than 1%. The range in annual deviations was 0.0%-2.4%. The slope of the regression line of Y+3 on Y was 0.997, which was not significantly ($P > 0.05$) different from 1 (Table III.7.6).

Table III.7.5. Average AEQs in year Y for legal-sized fish in SEAK fisheries, 1998-2007, as calculated by calibrations in year Y (preseason) and Y+3. Deviations (dev) are the percent differences between AEQs in Y+3 and Y, divided by AEQs in Y+3.

	Troll			Sport			Net		
Year	Y	Y+3	% dev	Y	Y+3	%dev	Y	Y+3	%dev
1998	0.934	0.928	0.7%	0.895	0.895	0.0%	0.870	0.887	-2.0%
1999	0.917	0.924	-0.8%	0.887	0.888	-0.2%	0.882	0.853	3.3%
2000	0.926	0.913	1.3%	0.896	0.885	1.3%	0.845	0.855	-1.2%
2001	0.912	0.913	0.0%	0.889	0.895	-0.6%	0.862	0.850	1.5%
2002	0.932	0.911	2.4%	0.909	0.899	1.1%	0.883	0.869	1.6%
2003	0.941	0.933	0.9%	0.915	0.914	0.1%	0.892	0.879	1.4%
2004	0.936	0.937	-0.1%	0.909	0.905	0.5%	0.880	0.882	-0.2%
2005	0.938	0.937	0.1%	0.921	0.910	1.2%	0.891	0.866	2.9%
2006	0.934	0.941	-0.7%	0.912	0.907	0.5%	0.840	0.876	-4.0%
2007	0.937	0.941	-0.4%	0.910	0.908	0.3%	0.884	0.868	1.8%
Average	0.931	0.928	0.3%	0.904	0.901	0.4%	0.873	0.869	0.5%

Table III.7.6. Regression slopes and 95% CI for the slopes of average AEQ values for legal-sized fish calculated in the Model calibration in year Y+3, and regressed on average AEQ values calculated in the Model preseason calibration for year Y. Regression lines were forced through the intercept.

Fishery	Gear	Slope	Lower 95% CI	Upper 95% CI
SEAK	Troll	0.997	0.990	1.004
	Sport	0.996	0.991	1.000
	Net	0.995	0.978	1.011
NBC	Troll	0.996	0.975	1.017
WCVI	Troll	1.002	0.988	1.016
	Sport	1.020	0.985	1.055

For the SEAK sport fishery, the average of the deviations was 0.4%, indicating slight positive bias in the preseason estimate relative to the subsequent calibrations (Table III.7.5). The average absolute deviation was less than 1%. The range in annual deviations was 0.0%-1.3%. The slope of the regression line of Y+3 on Y was 0.996, which was not significantly ($P > 0.05$) different from 1 (Table III.7.6).

For the SEAK net fishery, the average of the deviations was 0.5%, indicating slight positive bias in the preseason estimate relative to the subsequent calibrations (Table III.7.5). The average absolute deviation was 2%. The range in annual deviations was 0.2%-4.0%. The slope of the regression line of Y+3 on Y was 0.995, which was not significantly ($P > 0.05$) different from 1 (Table III.7.6).

For the NBC troll fishery, the average of the deviations was 0.4%, indicating slight positive bias in the preseason estimate relative to the subsequent calibrations (Table III.7.7). The average absolute

deviation was 1.9%. The range in annual deviations was 0.1%-7.1%. The slope of the regression line of Y+3 on Y was 0.996, which was not significantly ($P > 0.05$) different from 1 (Table III.7.6).

Table III.7.7. Average AEQs in year Y for legal-sized fish in NBC and WCVI fisheries, 1998-2007, as calculated by calibrations in year Y (preseason) and Y+3. Deviations (dev) are the percent differences between AEQs in Y+3 and Y, divided by AEQs in Y+3.

	NBC Troll			WCVI Troll			WCVI Sport		
Year	Y	Y+3	% dev	Y	Y+3	%dev	Y	Y+3	%dev
1998	0.907	0.896	1.2%	0.927	0.897	3.4%	0.917	0.909	0.9%
1999	0.888	0.884	0.5%	0.874	0.895	-2.3%	0.811	0.902	-10.1%
2000	0.894	0.866	3.2%	0.893	0.884	1.1%	0.792	0.895	-11.5%
2001	0.882	0.863	2.3%	0.866	0.877	-1.3%	0.875	0.882	-0.8%
2002	0.901	0.879	2.5%	0.902	0.880	2.5%	0.910	0.887	2.6%
2003	0.907	0.901	0.7%	0.897	0.907	-1.1%	0.908	0.915	-0.8%
2004	0.901	0.900	0.1%	0.901	0.901	0.0%	0.909	0.906	0.4%
2005	0.903	0.893	1.1%	0.899	0.901	-0.2%	0.906	0.902	0.4%
2006	0.845	0.910	-7.1%	0.881	0.894	-1.4%	0.898	0.904	-0.6%
2007	0.901	0.907	-0.7%	0.890	0.913	-2.6%	0.896	0.917	-2.3%
Average	0.893	0.890	0.4%	0.893	0.895	-0.2%	0.882	0.902	-2.2%

For the WCVI troll fishery, the average of the deviations was -0.2%, indicating slight negative bias in the preseason estimate relative to the subsequent calibrations (Table III.7.7). The average absolute deviation was 2.6%. The range in annual deviations was 0.0%-3.4%. The slope of the regression line of Y+3 on Y was 1.002, which was not significantly ($P > 0.05$) different from 1 (Table III.7.6).

For the WCVI sport fishery, the average of the deviations was -2.2%, indicating negative bias in the preseason estimate relative to the subsequent calibrations (Table III.7.7). The average absolute deviation was 3.0%. The range in annual deviations was 0.4%-11.5%. The slope of the regression line of Y+3 on Y was 1.020, which was not significantly ($P > 0.05$) different from 1 (Table III.7.6).

III.7.D Post-Season and Preseason Application of Average AEQ Values

Because the average AEQ values do vary to some degree (Section III.7.A), the use of annual estimates to calculate LCE scalars is preferred if the estimates are reliable and valid. As described in Section III.7.C.1, the average AEQ values did not change to any great degree from the first post-season calibration (year Y+1) relative to subsequent calibrations (year Y+3). The slopes of the regression lines between the calibration periods did not differ significantly from 1, where 1 indicates complete correspondence. Average deviations were less than 1.0%. These results indicate little to no bias in the Y+1 values. Thus, the use of the average AEQ values from the first post-season calibration to calculate AEQ scalars is recommended for post-season assessment of the TM in the AABM fisheries.

The average AEQ values from the preseason calibrations tended to be less stable than for the first post-season calibration. The average absolute deviations and the maximum annual deviations from the values at calibration Y+3 were generally higher for the preseason (Y) and first post-season (Y+1) calibrations (Figure III.7.6). For the SEAK fisheries and WCVI troll, the differences in average deviations and the range of annual deviations between the preseason and post-season calibrations are relatively small; for these fisheries, the average AEQ values from the preseason

calibration are adequate for calculating AEQ scalars for use in preseason estimates of total mortality. However, the wide range of annual deviations for the NBC troll and WCVI sport fishery could result in substantial error in preseason estimates of AEQ values used for LCE scalars. In such cases, it may be necessary to develop methods to reduce the preseason error in the AEQ estimates.

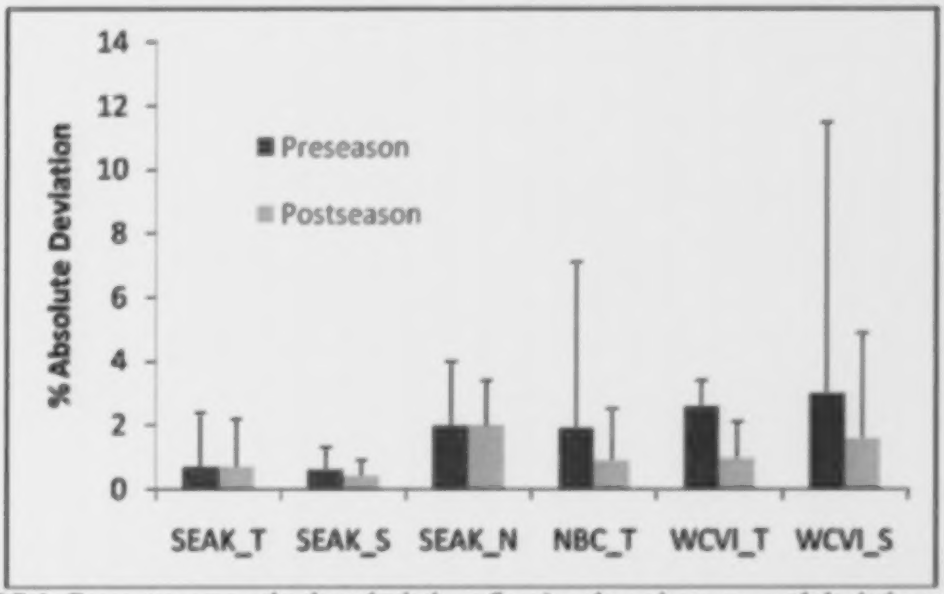

Figure III.7.6. Percent average absolute deviations (bars) and maximum annual deviations (lines) for average AEQs calculated for year Y preseason (year Y) or post-season (year Y+1) Model calibrations, in relation to values for year Y calculated in the Y+3 Model calibrations for 1998-2010.

Two approaches for improving the annual preseason estimates of average AEQs were tested for legal-size AEQs from the NBC troll and WCVI sport fisheries, 1998-2007. The first was to simply use the average of the three prior years AEQ values as the preseason estimate. The second was to use the regression of AEQs for year Y computed by the Model in year Y+3 on the AEQs computed by the Model preseason (year Y):

$$AEQ_{Lg,Y+3} = a + b^{*} AEQ_{Lg,Y} \qquad \text{(Equation III.7.1)}$$

A jackknife analysis was used to generate the regression over the years 1998-2007, so that the year estimated was not included in the regression. The preseason AEQ was then modified by multiplying by the slope and adding the intercept from the regression equation. Because the regression was being used for prediction, it was not forced through the intercept.

The prior-3 average approach improved preseason estimates of the average AEQ values for both the NBC troll and WCVI sport fisheries (Figure III.7.7). For NBC troll, the absolute average deviation relative to the value from calibration Y+3 was reduced from 1.9% to 1.5%, and the maximum deviation was reduced from 7.1% to 3.4%. For the WCVI sport, the absolute average deviation was reduced from 3.0% to 1.9%, and the maximum deviation was reduced from 11.5% to 5.7%.

The jackknife regression approach improved the WCVI sport preseason estimates, but did not improve the NBC troll preseason estimates (Figure III.7.7). For WCVI sport, the absolute average deviation was reduced from 3.0% to 1.0%, and the maximum deviation was reduced from 11.5% to 2.4%. For NBC troll, the absolute average deviation increased from 1.9% to 2.6%, and the maximum deviation increased from 7.1% to 10.6%.

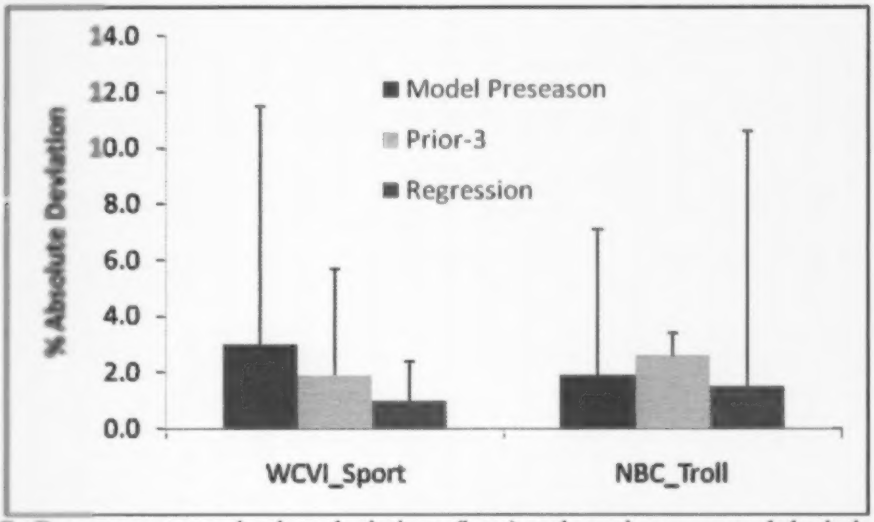

Figure III.7.7. Percent average absolute deviations (bars) and maximum annual deviations (lines) between preseason estimates (year Y) and calibration Y+3 estimates for average AEQs in the NBC troll and WCVI sport fisheries, 1998-2007, for three types of preseason estimates: (1) preseason (year Y) Model calibration; (2) prior three years average; and (3) preseason Model estimates modified by the regression relation of preseason estimates with estimates from the Y+3 Model calibration.

In summary, average AEQ values from first post-season calibrations and some preseason calibrations are sufficiently stable to use directly for calculating LCE scalars and estimating TM annually. But in some fishery by gear strata, substantial annual variability in preseason calibration estimates could introduce forecast error for the LCE scalars and thus for projecting TM. In such strata, the CTC may need to apply methods to reduce the error in preseason estimates of average AEQs. Preliminary investigation of two approaches to improving preseason estimates of average AEQs, (prior-3 averaging and a linear regression method) indicate that application of such methods may differ between fishery and gear strata.

III.8 STANDARDS FOR ESTIMATION AND IMPLEMENTATION

III.8.A Data Standards for Implementation of Total Mortality

The 2008 Agreement identifies the need for data standards to implement total mortality management. Paragraph 7(b) requires "*that, to implement total mortality management, estimates of the encounters of Chinook salmon are required, such that estimates: (i) are developed annually from direct observation of fisheries; or (ii) result from a predictable relationship reviewed by the CTC...*". 7(d) states, "*total mortality management will be implemented in all AABM fisheries in 2011, once the CTC advises and the Commission agrees that fishery-specific incidental mortality*

can be reliably estimated...". Appendix A (2) gives the CTC three technical assignments to develop two standards required to evaluate whether incidental mortality can be reliably estimated and predicted: "*a) Establish standards for the desired level of precision and accuracy of data required to estimate incidental fishing mortality (e.g., encounter rates, estimates of incidental and drop off mortality, stock specific mortalities of marked fish in selective fisheries) to be used for total mortality based management;...*", and "*d) Evaluate the accuracy of pre-season predictions of incidental mortalities*". Paragraph 7(g) also calls for an annual post-season assessment, including "*(i) a periodic evaluation of estimates of encounters and incidental mortalities in all fisheries, against standards developed by the CTC.*"

Pursuant to those tasks, the CTC will develop standards, as outlined in Table III.8.1, based on the following definitions:

1. Total Mortality (TM) = Landed Catch (LC) + Incidental Mortality (IM);
2. IM = (Releases * Release mortality rate) + (Encounters * Drop-off mortality rate); and
3. Encounters = LC + Releases,

whereby release mortality rates are needed for both legal and sublegal sized fish.

Table III.8.1. Data standards relevant to implementation of total mortality management.

Component	Standards and Criteria
Direct observations of encounters	• Acceptable methods for collecting direct observation data
Releases (for both sublegal- and legal-sized Chinook, by mark status, spatial and temporal strata, for each regulatory framework)	• Precision (CV) of release estimates • Representativeness of strata • Demonstration that new IM ratios are repeatable (e.g. across years) to propose a change from ratios used to revise Table 1
Estimates of incidental and drop-off mortality for legal- and sublegal-sized Chinook	• Precision and accuracy of release mortality rate • Precision and accuracy of drop-off mortality rate • When to use new rates based on statistical significance and magnitude of change (effect size)
Predictability of IM:LC relationship from past observational or other (e.g. Chinook Model) data	• E.g., regression relationship: Encounters=f(CNR effort or LC) • Standard error of regression • Variance of regression • Prediction intervals for $\hat{Y}$ (predicted values) • Precision (CV) of past observations of IM:LC • MAPE of hind-cast troll legal- and sublegal-sized Chinook encounters
Accountability of encounters and/or IM rates during total mortality implementation	• Precision • Adequate sample sizes to estimate encounters • Accuracy (validated against fisher-independent estimates): • Little or correctable bias • Statistically-based sample design, representative and comprehensive
Periodic evaluation of estimates for encounters and IM	• Frequency of re-evaluation • Standards for evaluation procedure

III.8.B Validation of Observed Estimates of IM

Encounter and incidental mortality rates are used to estimate incidental mortalities associated with landed catches, and are therefore key parameters in determining total mortality. The 1999 Chinook annex of the PST directed the CTC to improve the technical basis for estimating incidental mortality as a prerequisite for implementing total mortality management,

> *Improved estimates of incidental fishing mortality are to be developed based upon direct fishery observations. The CTC will collate and document existing information on the coastwide encounter rates for all sources of incidental mortality on Chinook coastwide. The CTC will report on the extent of incidental mortality and on deficiencies in the information coverage, and will recommend a work plan to address data deficiencies, including observer programs or other direct sampling procedures, that will enable implementation of a total fishing mortality regime.*

Subsequently, in 2004, the CTC completed the review and reported its' results (CTC 2004a). This report documents the encounter and incidental mortality rates used in the CTC Chinook model since 2004 and requires that any changes to incidental mortality rates be reviewed by the CTC prior to being used.

The 2008 Agreement states in paragraph 7(b) that "*to implement total mortality management, estimates of the encounters of Chinook salmon are required, such that estimates: (i) are developed annually from direct observations of fisheries; or (ii) result from a predictable relationship reviewed by the CTC between encounters and landed catch based on a time series of direct observations of fisheries.*" Further, in paragraph 7(d), that "*total mortality management will be implemented in all AABM fisheries in 2011, once the CTC advises and the Commission agrees that fishery-specific incidental mortality can be reliably estimated.*"

Historical data on incidental mortalities were used to construct IM:LC ratios required to translate LC into TM. Sections II.1 and III.4 describe the methods used to construct the IM:LC ratios. Historical data used for each year were either the best available data observed, or the best estimates available through less direct methods.

Implementation of a TM management regime will be a major change in accounting for AABM fisheries, which may have a profound impact on collection of encounter data. Prior to TM management, incidental mortalities were reported and accounted for, but they did not affect the landed catch estimates used to evaluate whether limits under Pacific Salmon Treaty management were exceeded. When TM management is implemented, there will be an incentive to further reduce IM. Under TM management, decreases in reliably estimated IM can ultimately result in increased allowable LC. However, this may create an incentive to underreport encounters, and further necessitates the need to validate encounters based on direct observations and to correct under-reporting biases.

Also, as new data are collected by scientifically sound studies on IM rates, there may be the desire to update the mortality rates being used by the CTC. Modifications to fishing gear and handling techniques, such as the use of barbless hooks or fish recovery tanks, have been shown to affect mortality rates of released fish (CTC 2004a). Again, since this is a key parameter in determining TM, a process is necessary to review agency proposals to change these rates, in order to ensure that

such proposals reflect improved estimates resulting from scientifically credible and well-designed studies, and that estimated mortality rates meet the data standards developed by the CTC.

The IM:LC ratios are used in both preseason planning and post-season assessment under TM regimes. In the absence of annual estimates from a validated monitoring program, the CTC will use historical relationships of IM:LC ratios to estimate TM. If an agency proposes a different relationship, the CTC will review the proposal and determine whether estimates of IM and TM would be improved, and whether the proposed rates will be adopted for post-season assessments by the CTC.

When a management agency proposes a change in incidental mortality rates, encounter rates, or IM ratios, the CTC will evaluate the proposals using the following process:

1. The agency proposing a change will provide the CTC with the rationale, data, and technical analyses to support the change. A proposal must be received by May 1 in order for it to be used for that year's post-season assessment.
2. The CTC will review the proposed change and supporting information at its next bilateral meeting and will prepare a memorandum with its recommendations to the agency and the PSC by the post-season PSC meeting.
3. CTC-approved changes will be used to determine the total mortality impacts that are evaluated against revised Table 1 limits.

III.9 DESCRIPTION OF CURRENT PROGRAMS TO MONITOR IM IN AABM FISHERIES

III.9.A SEAK AABM Fishery

III.9.A.1 SEAK Troll Fishery

Encounter estimates for the SEAK summer troll fishery are calculated using the regressions identified in Section III.4.A.1. The actual years with observer data used in the regression models are detailed in Appendix A. Encounter estimates for the SEAK winter and spring fishery are calculated as described in Section II.1.A.1. A direct observational program will need to take place occasionally to test whether the regression relationships between historical effort and encounters are still accurate. The cost of a direct observational program can be prohibitive. The last direct observational program in 2006 cost an estimated $208,000 (ADF&G 2006 LOA proposal N06-01) and used logbooks during the summer fishery only. Using observers to validate logbooks would require additional funding. The amount of additional funding depends on the number of fishing strata covered by observers. Two observers worked out of Sitka for two months during the summer of 2005 to validate logbooks in the northern outside fishing strata at a cost of around $28,000 (ADF&G 2005 LOA proposal C05-01). They observed 7 boat trips while 399 boat trips were reported in logbooks (ADF&G 2006 LOA N06-01 final report). During the summer of 2000 eight observers worked for two months throughout SEAK at a cost of approximately $74,000 (ADF&G 2000 LOA C00-01 proposal). They observed 55 boat trips while 176 boat trips were reported in logbooks (ADF&G 2006 LOA N06-01 final report). The cost of validating encounter estimates with observers would be higher than those presented above because observers would also be required for the winter and spring fisheries. Using video cameras onboard vessels to validate encounter estimates could provide an alternative to observer programs (see Section III.9.B.1).

III.9.A.2 SEAK Sport Fishery

Chinook encounters in the SEAK sport fishery are calculated from the SWHS as described in Section III.4.A.2. One caveat is that estimates from the SWHS are not available until the year after the fishery occurs. Creel surveys occur at the major SEAK ports and creel estimates are available during the current fishing year, but not all ports are covered so the creel encounter estimates only provide partial, preliminary estimates of encounters. Estimates of encounters from creel surveys might be useful to verify the SWHS encounter estimates for specific ports, but both creel and SWHS rely on data supplied by fishermen so an independent fishery observation program is still required to validate the creel and SWHS encounter estimates. No historical direct observation programs have occurred to validate encounter estimates in the SEAK sport fishery, so the cost of such a program is unknown. Costs of the troll programs indicate that validation of SWHS estimates would require an extensive and expensive observation program due to the large geographic range and large number of vessels in the SEAK sport fishing fleet.

III.9.A.3 SEAK Net Fishery

Encounter estimates for SEAK net fisheries are calculated as described in Section II.1.A.3. The historical relationship between encounters and seine catch described in Section II.1.A.3 is derived from 4 years of observational studies conducted from 1985-1988 and one year of a logbook study conducted in 2004[1]. Due to the limited dataset upon which the historical relationship is based, the relationship would need to be validated with more direct observational data to ensure the relationship is currently reliable. There are currently no direct observational programs to estimate or validate encounters of Chinook salmon in the SEAK net fishery. Again, due to the large geographic range and large number of vessels involved, a direct observation program to estimate and validate Chinook encounters is expected to be costly. The annual cost of the SEAK troll observer and logbook program funded by US LOA money from 1998-2006 grew from approximately $90,000 in 1998 to approximately $250,000 in 2006. Furthermore, by 2006 due to inflation and insurance costs, the program had become mostly a logbook program with few observers used on the outside coast for validation purposes. Current estimates of the cost of a full scale program using observers for either the SEAK net or troll fishery would be roughly twice as expensive ($500,000) as the cost of the troll logbook program in 2006.

III.9.B NBC AABM Fishery

III.9.B.1 NBC Troll Fishery

Encounter estimates for the NBC Troll fishery are calculated using the catch data from validated landings and release estimates from logbook data phoned into FOS. Logbook data are required as a condition of license. Landed catch of troll caught Chinook salmon are validated at the point the fish are removed from the vessel. Validation consists of a third party contractor that verifies the species, number, and condition (frozen or fresh) of the Chinook salmon off-loaded from the vessel. The validation contract is funded by the troll fishing industry in support of the Individual Transferrable Quota (ITQ) program and is integrated with the coded wire tag mark recovery program. The validated catch is essentially a census of the Chinook salmon caught by the NBC troll fishery, so release estimates from phoned-in logbook data are expanded by the ratio of validated catch to phoned-in catch to obtain total releases. Logbook data require this expansion to account for a small

[1] SEAK seine logbook data was also collected in 2005. However, there were no CNR periods in 2005 and therefore this year could not be used in the development of the relationship between encounters and landed catch.

portion of missing catch (often a result of license transfers or non-reporting). Vélez-Espino et al. (2010) developed correction factors for the reported numbers of Chinook salmon released by the NBC troll fishery based on the proportion released relative to landed catch and the releases per fishing effort. However, the observer data used to develop these relationships was from WCVI and may not relate well to the current NBC fishery because of changes in time and area and significant reductions in sublegal encounters in recent years (see Section V.5).

While reported Chinook releases are known to be underestimated because of under-reporting, the collection of direct observations to validate encounters has been largely unsuccessful in the NBC troll fishery. Observer programs attempted in 2000 and 2001 during pink and coho salmon fisheries on the A-B line were expensive and extremely unpopular with fishers. New technology using digital video and global positioning systems have been used successfully in the crab and rockfish fisheries in B.C. and elsewhere (McElderry et al., 2003, 2007) and could present an opportunity for the collection of high quality encounter data for the NBC troll fishery.

III.9.B.2 NBC Sport Fishery

Encounter estimates for the NBC sport fishery are based on estimates of releases from a creel survey conducted by the Haida Fisheries program and catch estimates derived from a combination of creel survey and logbook data. Voluntary logbooks are offered to lodges and charter operators. Currently all of the lodges participate in the logbook program, but only a portion of the logbook participants provide release data. Creel surveys are conducted from late May to mid-September and typically account for over 75% of the recreational Chinook catch. The creel surveys estimate total catch in Area 1 and non-lodge catch in Area 2W. Logbooks are used to fill in the lodge-based catch for Area 2W and to verify the lodge catch estimates in Area 1. Most release data are not size specific, but data available from a small portion of the logbooks indicate that most Chinook released in the NBC sport fishery are legal sized (>45 cm FL).

Chinook release estimates from the Haida creel survey are thought to be underestimated. A study conducted in 1999 showed that anglers that recorded releases on cards supplied daily for that purpose reported more releases than those that did not maintain the cards (Searing and Bocking 2000). The collection of direct observations to validate Chinook encounters in the NBC sport fishery has not occurred.

III.9.C WCVI AABM Fishery

III.9.C.1 WCVI Troll Fishery

Encounter estimates for the WCVI troll fishery are calculated using the catch and release estimates from logbook data phoned in to FOS. While logbook reporting is required as a condition of license, the catch and release estimates generated from logbooks often require adjustment to account for a small portion of missing catch (resulting from non-reporting or under-reporting). The following sources of information may be used to adjust the catch and release estimates: validated catch from dockside sampling programs (i.e. through the CWT mark-recovery program); sales slip information; data from on-board observers; or monitoring information gathered through enforcement programs.

It should be noted that in contrast to the NBC troll fishery, there is currently no Individual Transferable Quota (ITQ) program in place for the WCVI Troll fishery. Therefore, only a portion of catch is validated at landing sites through the CWT mark-recovery program (i.e. about 20%).

Vélez-Espino et al. (2010) concluded that Chinook releases are underestimated in the WCVI troll based on comparing logbook data from vessels with observers to logbook data from vessels without observers fishing during similar times and locations. Based on their analysis, they developed correction factors to expand the reported releases of Chinook in the fishery.

III.9.C.2 WCVI Sport Fishery

The WCVI AABM sport fishery operates year round. However, most of the effort is concentrated from the June to September period. Target species vary from time and area. Offshore fisheries generally target Chinook or halibut, but also catch coho. Encounter estimates for the WCVI sport fishery are based on estimates of catch and release derived from the WCVI Creel Survey program. This information is either augmented or adjusted with additional information gathered through voluntary logbook data provided by charter operators and fishing lodges.

Creel surveys are conducted from mid-June to mid-September. There are two major components of the Creel Survey: angler interviews which occur at landing sites throughout the WCVI and aerial surveys of effort. During interviews, anglers are requested to provide catch and release by species, area and time in addition to other information. The unit effort is considered a boat trip. About 10% of the effort is surveyed in the time and areas where the Creel Survey operates. In areas where the Creel Survey does not operate, such as area 26, the sole source of catch and release information is through logbooks provided by sport lodges. The logbook estimates from this area are adjusted upwards to account for non-guided boat-trips based on aerial effort surveys. In other areas where the Creel Survey operates, logbooks may be used to adjust the catch and release estimates based on guided trip CPUE which is typically higher than non-guided CPUE (i.e. catch and release may be adjusted upward).

It is not known whether Chinook release estimates from the WCVI Creel Survey are underestimated or overestimated, although recall information on release rates is considered very unreliable. On the one hand, anglers may not recollect all encounters, particularly if the encounter rate is high. On the other hand, they may be prone to exaggeration at the landing site for prize species such as Chinook. The collection of direct observations to validate Chinook encounters in the WCVI sport fishery has not occurred. However, within a boat trip, most anglers do not achieve their legal bag limit for Chinook in the WCVI AABM recreational fishery.

IV ANALYSIS OF APPLICATION OF TM LIMITS TO CURRENT FISHERIES

The development of the Table 1 with TM limits for the AABM fisheries described in Section II.2.E (see Table II.2.22) is based on the allocation between gear groups assumed in Chapter 3, Appendix B of the 2008 Agreement; and on the 1985-1995 IM:LC ratios and average AEQ values. Actual LC and TM resulting from managing to the limits defined in the TM Table 1 may differ from the current levels of TM and LC for at least the two following reasons: 1) variation of the allocation among gear groups relative to that assumed in Chapter 3, Appendix B of the 2008 Agreement; and 2) temporal changes in the IM:LC ratios since the 1985-1995 base period. Section III.2 describes the deviation of current management allocations from the assumptions in Appendix B. Sections III.3 and III.4 describe the substantive changes in IM:LC ratios since the 1985-1995 base period and the effects these changes have had on IM. This section of the report examines the average expected effect of these changes on TM and LC for each AABM fishery under a TM regime.

These analyses should be viewed in the context of several caveats:

- The results assume perfect management of fisheries to achieve LC and TM limits for each component gear sector. In reality, uncertainty in abundance and inseason catch monitoring, and area-specific conservation issues will result in overages and underages.
- The effects are based on average IM rates and AEQs. As such, the results are a reasonable estimation of average effects, but interannual variation in these parameters will affect actual realized TM.
- The PSC Chinook Model does not take into account variations in fishery stock composition that result from changes to the time area stratification of the catch. This is also an issue under the current LC regime. Changes in the Model to account for such variation will result in changes to the AI:LC relationship in either an LC or TM regime (see Section V.2).

IV.1 EFFECT OF CHANGES IN LC ALLOCATIONS AMONG GEAR SECTORS

IV.1.A SEAK AABM Fishery

For the SEAK fishery, the relationship in Appendix B uses a fixed LC of 17,000 for the SEAK net fishery at each AI, with 80% of the remainder apportioned to the troll fishery and 20% to the sport fishery. These sector allocations were used to compute the gear-specific TM in LCEs for each gear group, which were then summed for the fishery AABM limit in Table 1 for SEAK (see Section II.2.B). The current allocation policy implemented by the Alaska BOF calls for the SEAK allowable landed catch to be managed such that 1,000 Chinook are allocated to the set-net gillnet fishery; 7.2% to the drift gillnet and purse seine fisheries (2.9% gillnet, 4.3% purse seine); and the remainder is divided such that 80% is allocated to commercial troll and 20% is allocated to sport.

To determine the potential effect of the current BOF allocation strategies on LC under a TM regime relative to a LC regime, estimated LC was computed for the TM limits for each AI in TM Table 1 using the BOF allocations. The assumed IM:LC ratios (Table II.2.1) for each gear type and the AEQ scalars for converting LCEs between gear types (Table II.2.2) were taken from the 1985-1995 base period. The initial estimates of LC in the TM Table 1 (under the Appendix B assumptions)

were used to develop initial estimates of LC for each of the component gear types using the BOF allocation. The TM for the initial estimate of LC in the net fishery was then calculated using ratios in Table II.2.1, and translated into TCEs using Table II.2.6. The allowable net catch in TCEs is then subtracted from the all-gear TM limit and the remaining LCEs for the TM limit are allocated among the troll and recreational sectors. The initial estimate of the LC in the net fishery was then iteratively adjusted using EXCEL Solver so that the projected LC for troll and sport combined was 80% troll, 20% sport in LC, with TM summed across all gear sectors equal to the TM limit at that AI.

Potential LC for the BOF allocation under TM management, relative to current LC management, was projected to be higher at low AIs and similar or slightly lower at high AIs over the range of AIs in Table 1 (Figure IV.1.1). The change in impact as the AI increases is due to the fact that the fixed net allocation under the Appendix B assumptions becomes an increasingly smaller proportion of the catch as AI increases. Because the net fishery has the highest associated IM (Table II.2.2), less TM is caused by the net fishery under the BOF allocation. Therefore, more of the TM limit can be allocated to the troll and sport fisheries, which have lower associated IM resulting in higher projected LC within the TM limit.

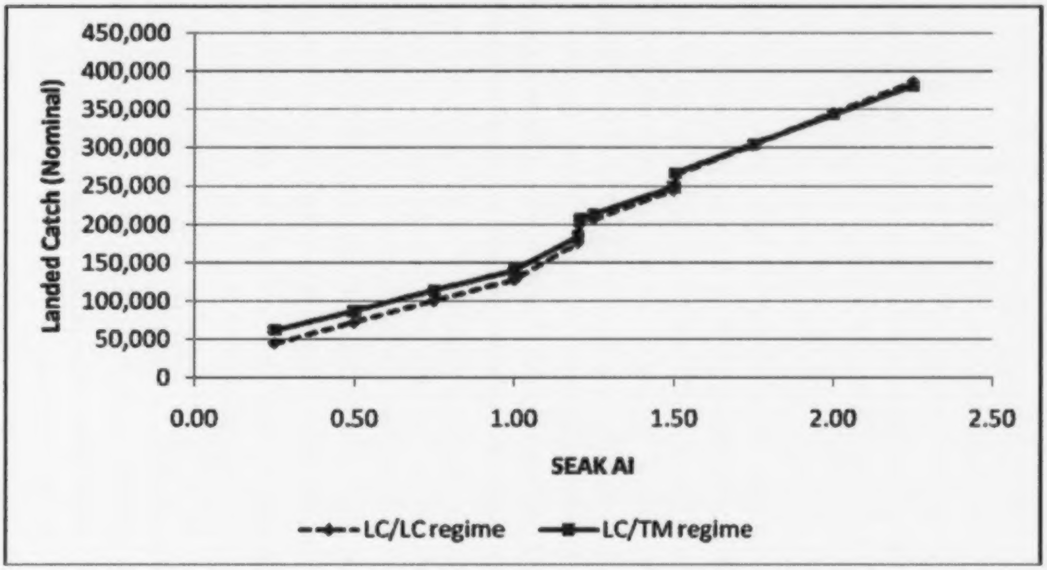

Figure IV.1.1. Potential nominal LC of Chinook salmon in the SEAK AABM fishery for the range of AIs in Table 1 for LC and TM management regimes.

The impact of the difference between Appendix B allocation assumptions and the BOF allocation scheme is small and variable over the range of AIs observed for the SEAK fishery. From 1985 to 2009, AIs in the SEAK fishery have ranged from around 0.9 to 2.2 and have averaged 1.52 (Calibration 0907). The expected differences in LC due to using the BOF allocation under a TM regime range from 6% higher at the low end of the observed AI range to 1% lower at the high end of the range, with no difference at an AI of 1.51 (Figure IV.1.2).

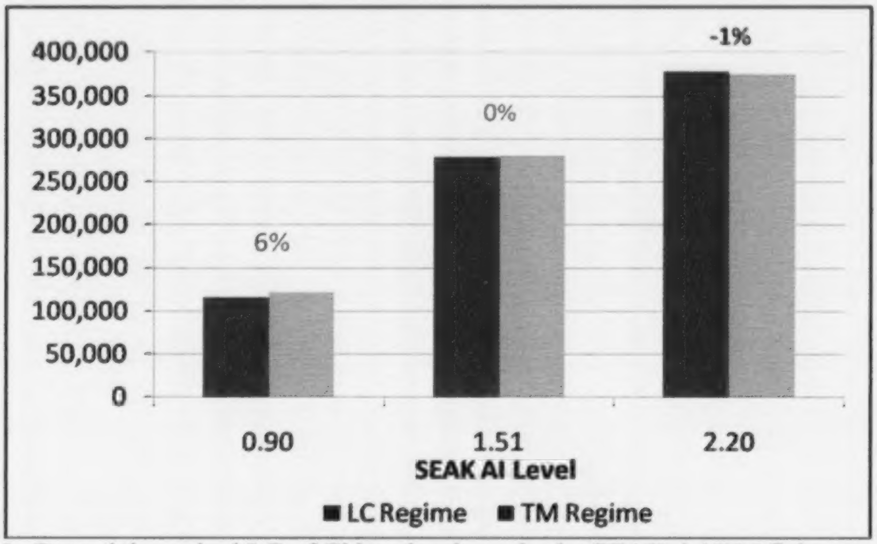

Figure IV.1.2. Potential nominal LC of Chinook salmon in the SEAK AABM fishery under an LC regime and a TM regime using the BOF allocation scheme at low, average, and high AIs observed for SEAK, 1985-2009. Values above the bars are the estimated percentage change in LC for the TM regime relative to the LC regime.

IV.1.B NBC AABM Fishery

For the NBC AABM fishery, LC at each AI in Table 1 under a LC regime or TM under a TM regime assumes that the total AABM catch will be composed of 20% from the sport sector and 80% from the troll sector. The allocation policy followed by CDFO, however, is quite different in practice. The sport sector is not managed according to a specific quota although for preseason fishery planning purposes, the sport sector is allocated a number of fish which is unlikely to be exceeded given expected effort and catch rates of Chinook salmon in recent years. For the NBC sport fishery, the management allocation has been 40,000 Chinook with the remainder out of the total allowable catch (as determined by the preseason AI from the PSC Chinook Model projection) allocated to the troll sector. Under a LC regime, the 40 K sport allocation equals the 20% assumed in Table 1 at a total LC of 200,000 and a corresponding AI of 1.50. Below this AI, the 40 K allocation will exceed the 20% contribution to total LC and above it, it will be less.

To investigate the effect of this standard CDFO allocation policy for the NBC AABM fishery, the total nominal LC was determined under a TM regime assuming base period IM rates for both troll and sport sectors but allowing for a fixed nominal LC of 40 K to the sport sector. The troll sector was allocated the remaining (and thus changing) LC at each AI. EXCEL Solver was employed to iteratively adjust the total LC such that all categories of IM and LC from both sectors equaled the total TM specified in TCEs at each AI. The total IM:LC ratio is about 30% lower for the sport sector compared to the troll sector (0.178 vs. 0.246; see Table II.2.8) and consequently, potential LC gradually increases below the AI value (1.50) at which the sport allocation exceeds 20% (Figure IV.1.3). Above this AI, potential LC gradually decreases as the percentage contribution from the sport sector decreases. These changes to LC under a TM regime compared to a LC regime are small (undetectable in Figure IV.1.3). They are so small that they can be considered negligible. Figure IV.1.4 better illustrates just how minor is the effect of the allocation to the sport sector. It shows a comparison of the potential LC under the TM regime compared to LC under a LC regime

at three different AI levels, low, average and high, as observed in the period 1999-2008. The difference in LC at each of the three AIs is <±1%.

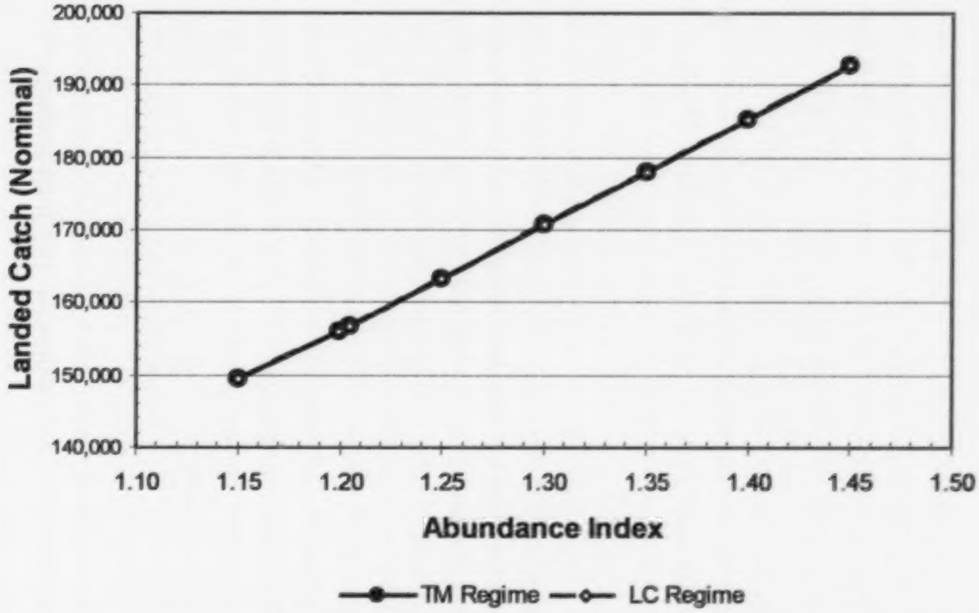

Figure IV.1.3. Potential nominal LC under the current LC regime and under a TM regime for the aggregate NBC AABM fishery across a range of AI values spanning the mean AI observed from 1999-2008. The LC under the LC regime is from Table 1 from the 2008 PST and assumes a 20% sport contribution to LC. LC under the TM regime assumes a preseason sport LC management objective of 40,000 fish. It is derived given the TM target from a Table 1 which is based on 1985-1995 IM rates and a 20% allocation to sport in the aggregate LC.

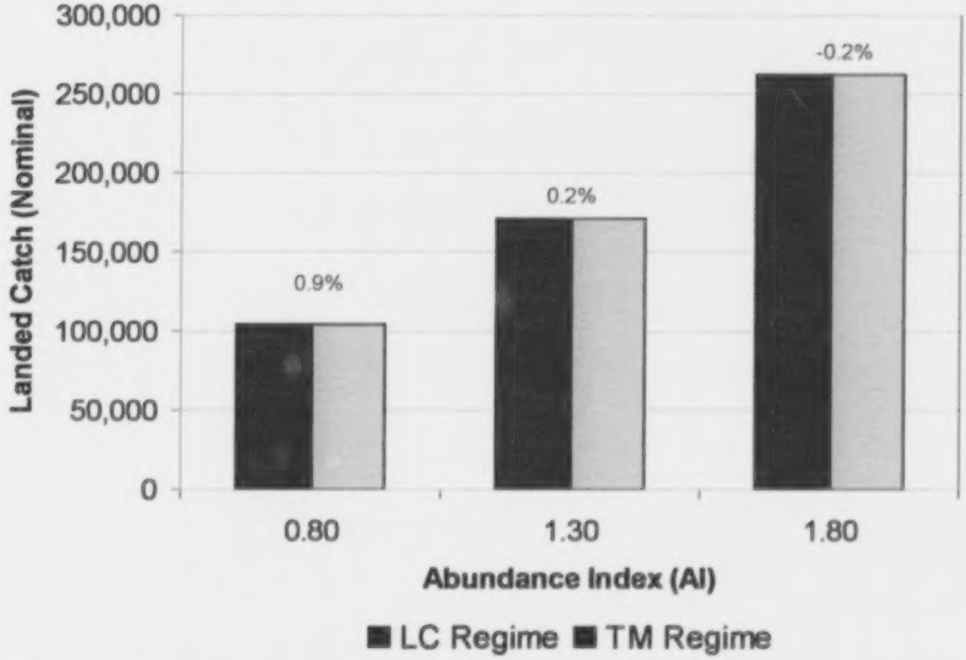

Figure IV.1.4. Potential nominal LC of Chinook salmon in the NBC AABM fishery under an LC regime and under a TM regime which allows for a preseason management allocation to the sport sector of 40,000 Chinook at low, average, and high AI levels observed in the period 1999-2008. The value above each bar is the estimated percentage change in LC under the TM regime relative to LC under the LC regime.

The effect of the allocation to sport under a TM regime was also investigated by a second approach. Potential LC was determined by varying the percentage contribution by the sport sector to the total LC at a single AI. The effect would be similar at any AI but the average AI of 1.30 observed from 1999-2008 was chosen for illustration. Under this scenario, LC under a LC regime remains constant at a given AI regardless of shifts in the allocation between the sport and troll sectors. LC under a TM regime was obtained using EXCEL Solver to iteratively determine the total nominal LC given the TM target in TCEs and assuming base period IM rates for each category of mortality under the troll and sport sectors. As would be expected, total LC increased in comparison to LC under a LC regime when the percentage contribution by the sport sector exceeded the 20% level assumed in Table 1. Total LC decreased when the sport contribution was less than 20% but the effect is small (Figure IV.1.5). At the average AI of 1.30 and the average percent contribution by sport sector (~40%) in the total observed LC from 1999-2008, the potential increase in LC would be <1% equating to about 1,600 additional Chinook. In conclusion, allocation changes in the NBC AABM fishery would have only a minor effect on potential LC under a TM regime developed using data from the 1985-1995 base period.

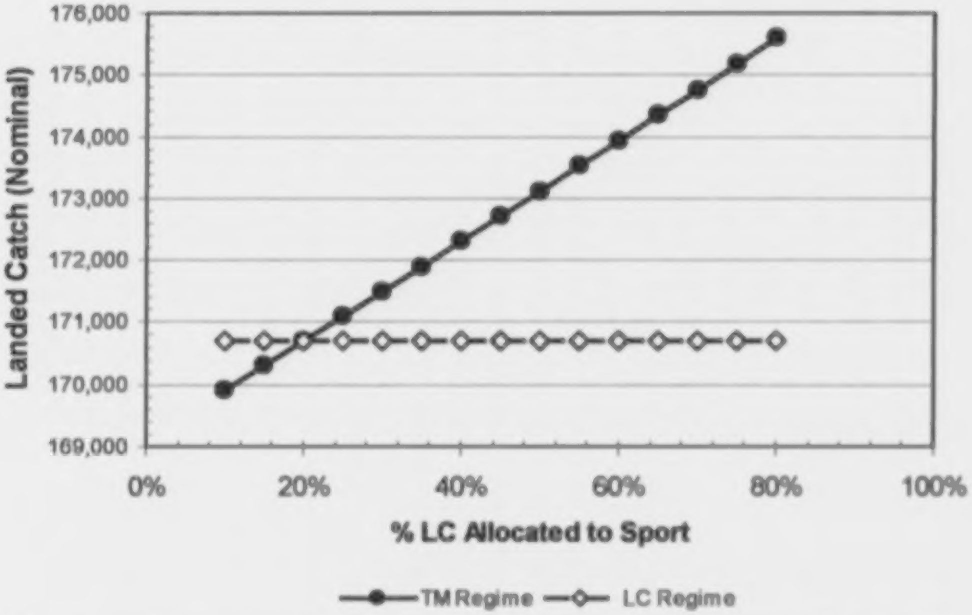

Figure IV.1.5. Potential nominal LC under the current LC regime and under a TM regime for the aggregate NBC AABM fishery under a varying percentage allocation to NBC sport out of the total LC at an AI level of 1.30. The LC at this AI is always 170,700 Chinook under the current LC regime. The 1999-2008 observed preseason average AI for this fishery is 1.33 (range: 0.96 – 1.69).

IV.1.C WCVI AABM Fishery

The relationship between the AIs in Table 1 and LC for the WCVI AABM fishery assumes an underlying allocation of 20% from the sport sector and 80% from the troll sectors to the aggregate nominal LC. This is the same allocation structure as employed in the construction of Table 1 for NBC AABM fishery under both the 1999 and 2008 Agreements. Just as with the NBC AABM fishery, however, the allocation policy used by CDFO fishery management is quite different. The sport sector is not managed to a quota or target and for preseason planning purposes, a fixed allocation of 50,000 Chinook is used, a catch that is unlikely to be exceeded given effort estimates and catch rates from recent years. The remaining LC out of the total allowable catch given the preseason AI projected by the Chinook Model is then allocated to the troll sector.

The effect of the CDFO allocation policy on potential LC under a TM regime was investigated for the WCVI AABM fishery in the same way as described in the preceding section for the NBC fishery. LC under a TM regime was obtained using EXCEL Solver which iteratively adjusted the total LC until all categories of IM and LC from both sectors equaled the total TM specified in TCEs at each AI. Base period IM rates and scalars were used in the calculations of LC. LC under a LC regime was taken from the current Table 1. The total IM rate incurred by the sport sector was about half that for the troll sector (0.381 vs. 0.191; see Table II.2.15). This is due mostly to the considerably lower minimum size limit (45 cm) in effect compared to either of the size limits that were used for the troll fishery (62 cm and 67 cm) during the years of the base period, 1985-1995. The lower IM incurred by the sport fishery translates into higher potential aggregate LC under a TM

regime compared to a LC regime over the range of AIs which have been observed in the recent period, 1999-2008, for this AABM fishery (Figure IV.1.6). The estimated percentage gain in LC relative to the LC under a LC regime is shown at three AI levels, low, average and high in Figure IV.1.7. The potential LC is higher at each AI level but the effect of the allocation change to that assumed in Table 1 is quite modest. For example, the potential gain in LC is around 5% at an AI of 0.50, a low value for this fishery. This increase is less than the average coefficient of variation estimated for the annual WCVI sport LC (average = 7% from 2000-2005).

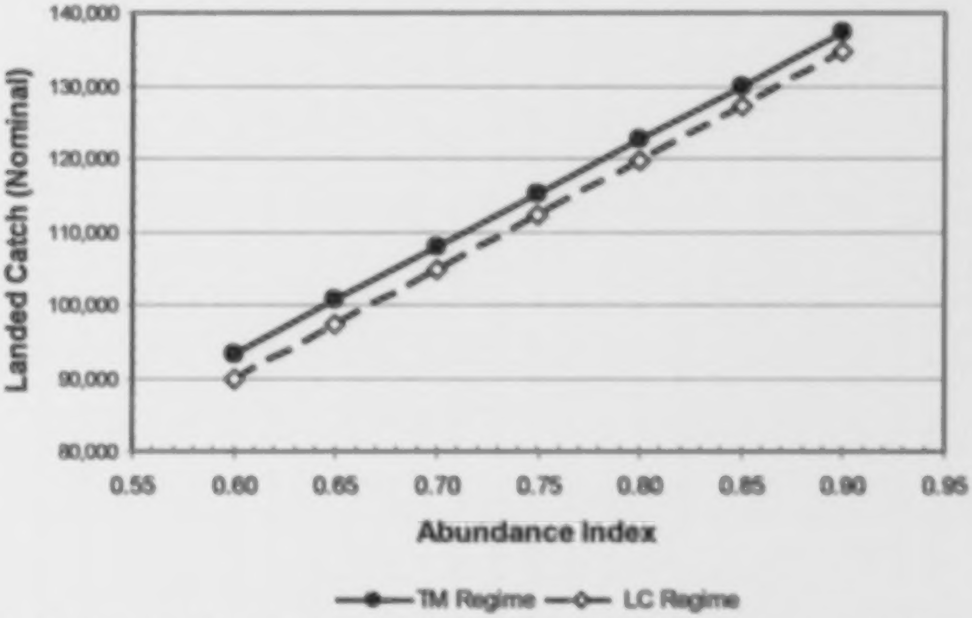

Figure IV.1.6. Potential LC under the current LC regime and under a TM regime for the aggregate WCVI AABM fishery across a range of AI values spanning the mean AI observed from 1999-2008. The LC under the LC regime is from the Table 1 from the 2008 PST and assumes a 20% sport contribution to LC. LC under the TM regime is derived allowing for a preseason sport LC management objective of 50,000 Chinook but using the TM target from a Table 1 developed from 1985-1995 rates and assuming the 20% allocation to sport in the aggregate LC.

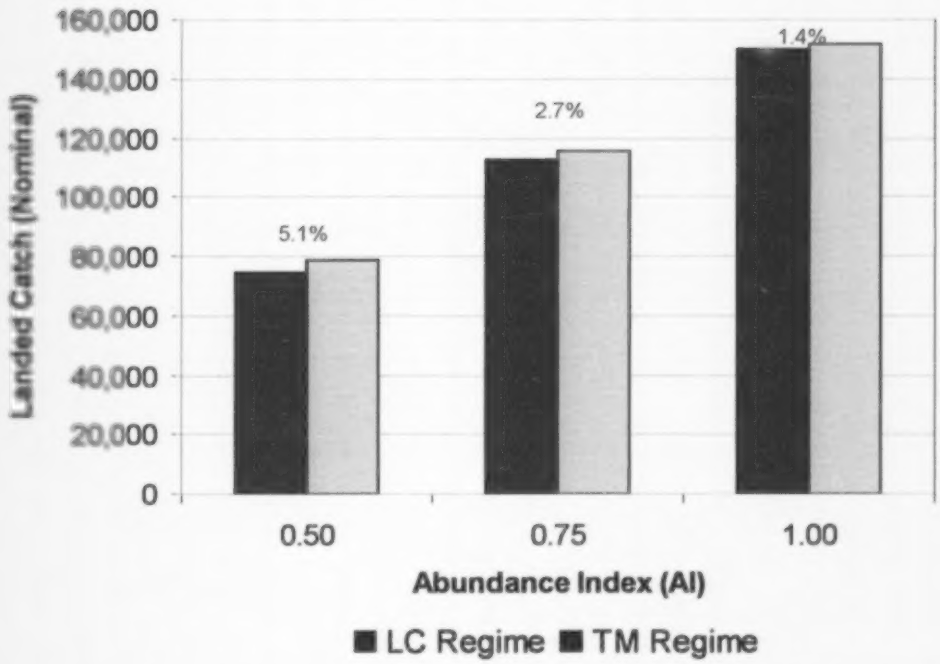

Figure IV.1.7. Potential nominal LC of Chinook salmon in the WCVI AABM fishery under a LC regime and under a TM regime which allows for a preseason management objective of 50,000 Chinook at low, average, and high AI levels observed in the period 1999-2008. The value above each bar is the estimated percentage change in LC under the TM regime relative to LC under the LC regime.

The percentage gain in LC decreases gradually as the AI increases and becomes zero at the AI at which the 50 K allocation to the sport sector equates to 20% of the total LC. This occurs at a LC of 250,000 and the corresponding AI of 1.46. Above this AI, potential LC under a TM regime would gradually decrease relative to LC under a LC regime. The highest AI estimated by the PSC Chinook Model for this fishery is 1.16, the value assessed postseason for 2002.

As was done for the NBC AABM fishery, the effect of altering the LC allocation to sport and troll assumed in Table 1 was investigated by determining the potential LC under a TM regime as the percentage LC contribution by the sport sector to the aggregate LC was varied at a single AI. The average AI observed from 1999-2008 was chosen to illustrate the effect but the effect would be similar at any AI. EXCEL Solver was used as before to obtain the potential LC given the TM target in TCEs at an AI of 0.75. Base period IM rates and scalars were used to find the iterative solution at each percentage contribution to LC by the sport sector. The results of the analysis showed predictably that at percentages less than the 20% assumed in Table 1, the potential LC was slightly less than that under a LC regime (Figure IV.1.8). At the 20% contribution level, the difference in LC under the two management regimes would be zero. Above the 20% contribution level, potential LC would increase as the percentage contribution increased. At the 50% level, the potential increase in LC is modest (3.4%) equating to about 3,900 Chinook. The mean contribution by the WCVI sport sector to the observed LC from 1999-2008 was about 33%.

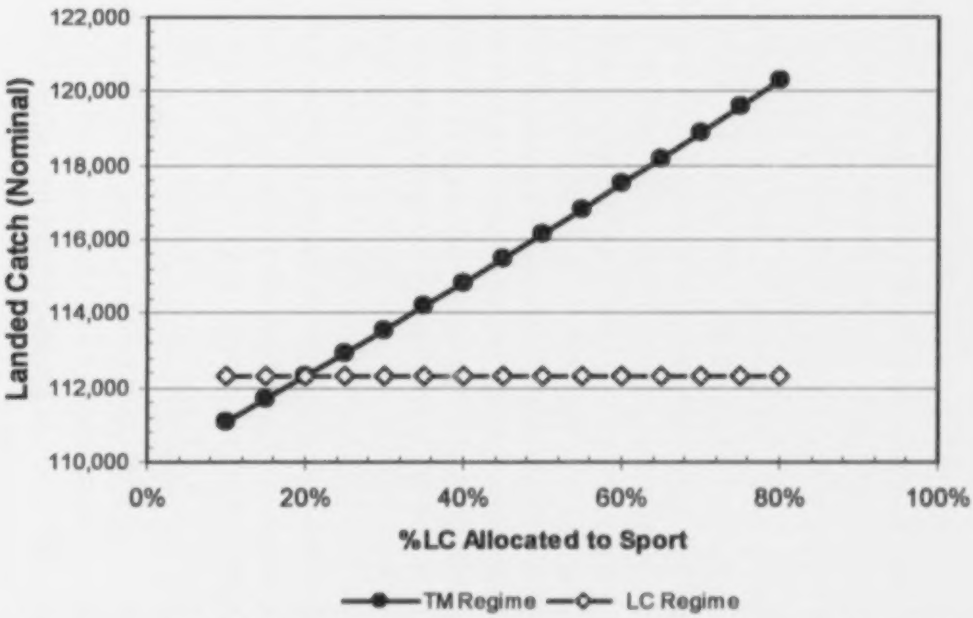

Figure IV.1.8. Potential LC under the current LC regime and under a TM regime for the aggregate WCVI AABM fishery under a varying percentage allocation to WCVI sport out of the total LC at an AI level of 0.75. The LC at this AI is always 112,300 fish under the current LC regime. The 1999-2008 observed preseason average AI for this fishery is 0.76 (range: 0.54 – 0.95).

IV.2 EFFECT OF TEMPORAL CHANGES IN IM:LC RATIOS

IV.2.A SEAK AABM Fishery

The effects of temporal changes in IM ratios on TM and LC in the SEAK fishery were evaluated with the 1999-2008 average IM ratios and AEQs and current BOF current allocations to estimate (1) current TM under the LC limits defined by the LC Table 1; and (2) the potential landed catch under the TM limits from the TM Table 1.

The 1999-2008 IM ratios used to represent current conditions were reported in Section III.3.A and are summarized in Table IV.2.1. The 1985-1995 base period IM ratios used for developing the TM Table 1 in Section II.2.B are also included in Table IV.2.1 to contrast the time periods. The average LIM:LC ratios were lower in 1999-2008 for the troll and net sectors by 45% and 85%, respectively, although LIM:LC increased by 10% for sport. For the SIM:LC ratios, all sectors were lower in 1999-2008, troll by 54%, sport by 21%, and net by 84%.

Table IV.2.1. Average ratios of LIM:LC and SIM:LC for the SEAK troll, sport and net gear sectors for the 1985-1995 base period and the 1999-2008 current period.

Ratio Statistic	1985-1995			1999-2008		
	Troll	Sport	Net	Troll	Sport	Net
LIM:LC	0.102	0.093	0.274	0.056	0.102	0.041
SIM:LC	0.237	0.169	1.171	0.097	0.133	0.183

The average AEQ scalars for 1999-2008 used to estimate LCEs within gear sector for the SEAK AABM fishery are summarized in Table IV.2.2. The 1985-1995 base period average AEQ scalars used for developing the TM Table 1 in Section II.2.B are also included in Table IV.2.2. In contrast to the IM ratios, the average AEQ scalars for LCE changed relatively little between time periods. The scalars increased less than 1.0% for troll and sport, and by 3.0% for net.

Table IV.2.2. Average AEQs for legal (LC) and sublegal (SL) sized fish and the ratio of sublegal AEQ to legal AEQ estimates by gear sector for the SEAK AABM fishery, 1985-1995 and 1999-2008.

AEQ Statistic	1985-1995			1999-2008		
	Troll	Sport	Net	Troll	Sport	Net
$AEQ_{\ell L}$	0.928	0.899	0.844	0.930	0.901	0.864
$AEQ_{\ell SL}$	0.684	0.657	0.657	0.680	0.653	0.653
LCE_{ℓ}	0.736	0.731	0.779	0.732	0.725	0.756

The average AEQ-based scalars for 1999-2008 used to convert LCEs to troll LCEs (TCEs) for the SEAK AABM fishery are listed in Table IV.2.3. The 1985-1995 base period average AEQ scalars used for developing the TM Table 1 in Section II.2.B are also included in Table IV.2.3. The scalar was by definition identical for both time periods for troll. It also remained the same for sport, and increased by just 2.2% for net.

Table IV.2.3. Scalars for converting sport and net gear-specific LCEs to TCEs for SEAK AABM fishery for the 1985-1995 base period and the 1999-2008 current period.

Gear Sector	Scalar for conversion to TCE	
	1985-1995	1999-2008
Troll	1.00	1.00
Sport	0.97	0.97
Net	0.91	0.93

To calculate the TM under the current LC regime, the associated IM for the LC for each gear sector was calculated using the 1999-2008 ratios in Table IV.2.1. The SIM was converted into LCEs for each gear sector using the LCE scalars for 1999-2008 in Table IV.2.2. The LC, LIM, and SIM was then summed for each gear sector, and converted to TCEs using the scalars for 1999-2008 in Table IV.2.3. The TCEs at a given AI for each gear sector were then summed to generate the estimate of TM for that AI. The full table of the calculated TM across all gear sectors is in Appendix D.

To calculate the potential LC under a TM regime, the LC from the current LC Table 1 was again apportioned among the three gear sectors according to the BOF allocation for each AI listed in Table 1 and the associated TM was calculated. An EXCEL Solver routine was then used to iteratively increase all-gear LC, which was re-apportioned among the gear groups according to the BOF allocation, and the TM for each gear group recalculated. This process continued until the TM across all gear equaled the TM limits in the TM Table 1 developed in Section II for each AI in Table 1. The full table of the calculated LC across all gear sectors for the TM Table 1 is in Appendix D.

The temporal changes in IM ratios resulted in substantial estimated increases in both TM and LC should TM management be implemented. (Figure IV.2.1). The proportional increases from the LC regime were similar for TM and LC, and were higher at lower AI levels. From 1985-2009, AIs in the SEAK fishery have ranged from 0.9 to 2.2, and averaged about 1.52 (Chinook Model calibration 0907 results). The potential increase in TM and LC from current estimated levels under a TM regime was 24% at the low end of this range, and 17% at the high end, with an increase of 18% at an AI of 1.51 (Figure IV.2.2.and Figure IV.2.3).

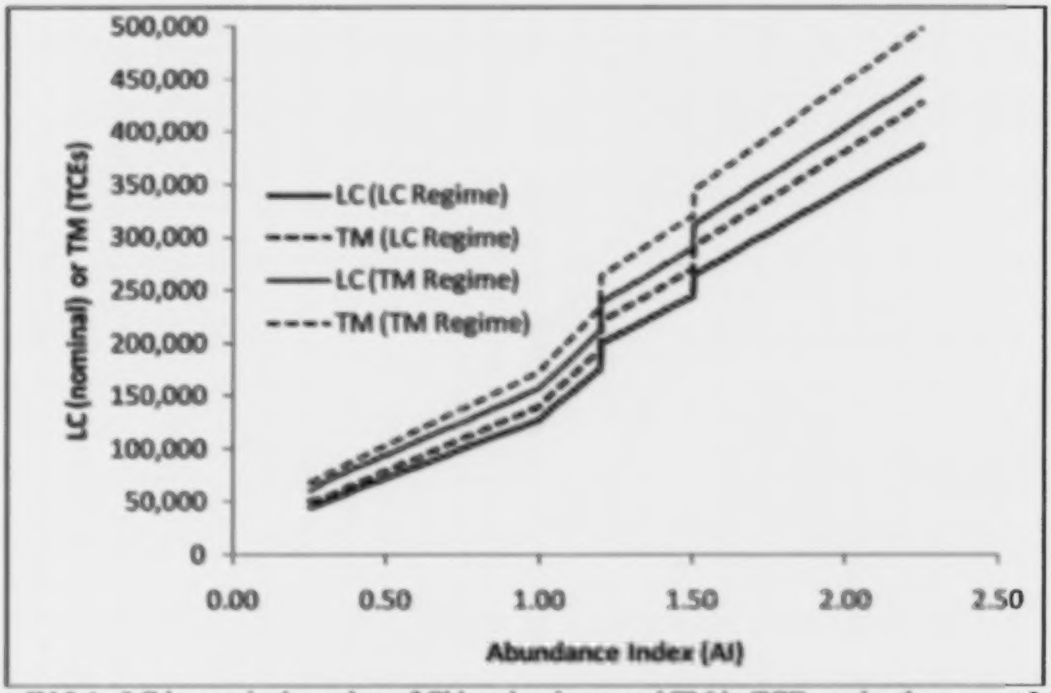

Figure IV.2.1. LC in nominal number of Chinook salmon and TM in TCEs under the current LC regime and projected under a TM regime for the SEAK AABM fishery.

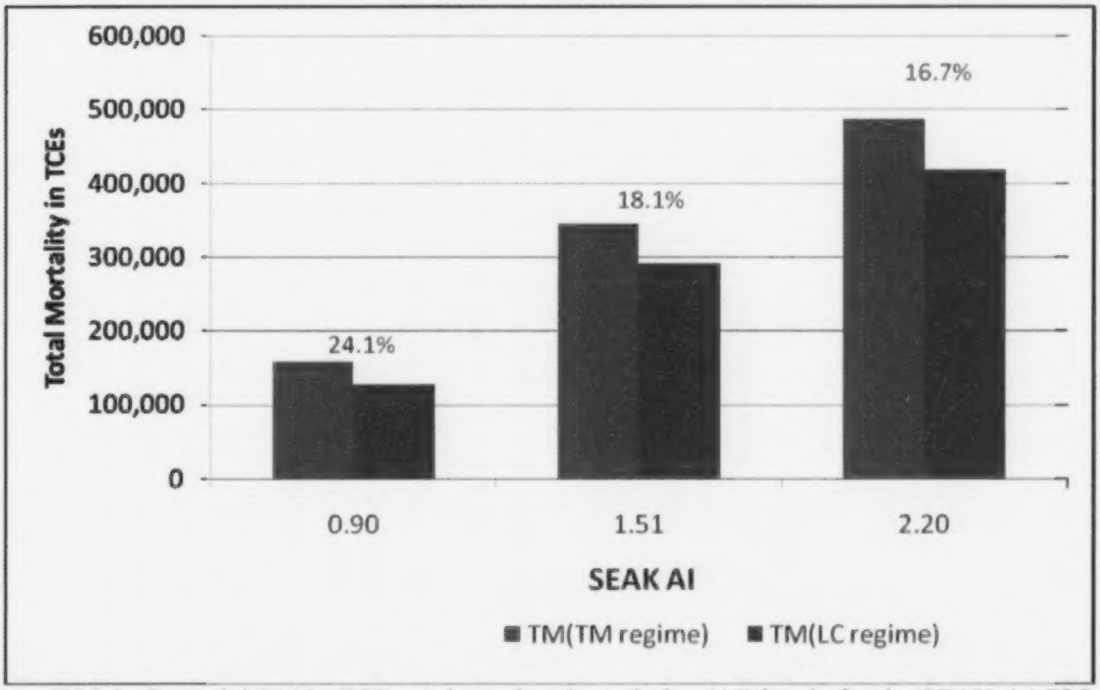

Figure IV.2.2. Potential TM in TCEs at three abundance index (AI) levels for the SEAK AABM fishery under a TM regime and the LC regime. Numbers above the bars are the percentage increases in TM for the TM regime.

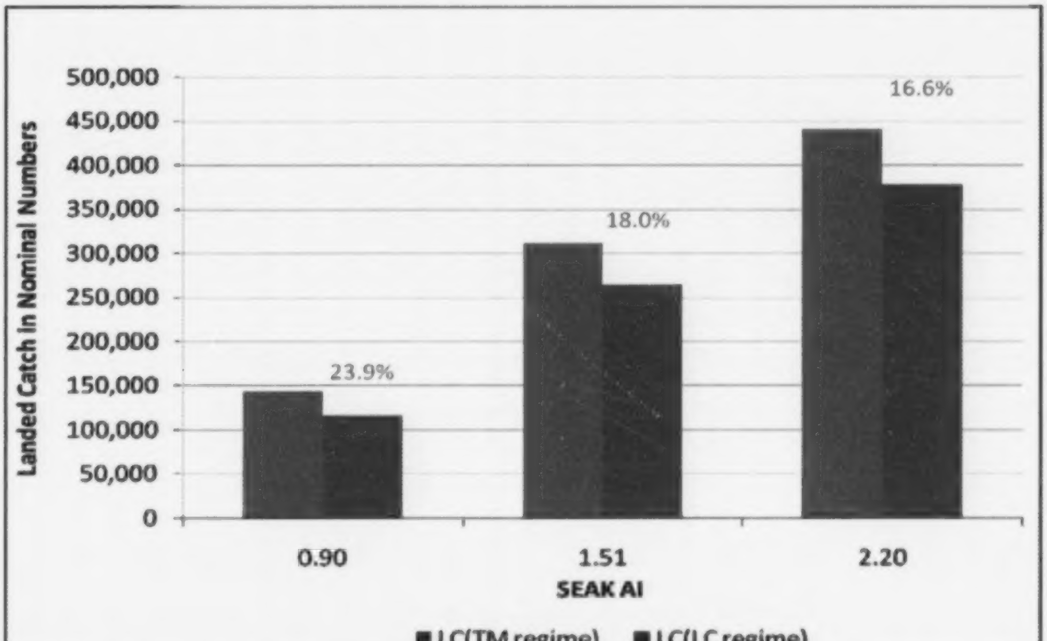

Figure IV.2.3. Potential LC in nominal numbers of Chinook salmon at three AI levels for the SEAK AABM fishery under a TM regime and the current LC regime. Numbers above the bars are the percentage increases in LC for the TM regime.

IV.2.B NBC AABM Fishery

The effects of temporal changes in IM rates and scalars were investigated in essentially the same manner for the NBC AABM fishery as was done for the SEAK AABM fishery in the preceding section. First, an estimate of TM expressed in TCEs was derived from LC at each AI in Table 1 using rates and scalars developed from the recent period 1999-2008. The development of average LIM:LC and SIM:LC ratios for this period for NBC troll and sport was described in detail in section III.4.B. These ratios for the base period (see Table II.1.17and Table II.1.21) and for the more recent period (see Table III.4.13 and Table III.4.16) showed some notable changes (Table IV.2.4). While there was a modest increase in the troll LIM:LC average ratio (6.5%) and a modest decrease in the sport LIM:LC ratio (6.2%) from the earlier period to the more recent one, the greatest change was the large decrease in troll SIM:LC (91.5%). There was no change in the sport SIM:LC ratio because the rarity of encounters with sublegal-sized Chinook salmon is assumed to have been similar between the two time periods.

Table IV.2.4. Average ratios of LIM:LC and SIM:LC for NBC troll and sport for the 1985-1995 base period and the 1999-2008 recent period.

Ratio Statistic	1985-1995		1999-2008	
	Troll	Sport	Troll	Sport
LIM:LC	0.029	0.178	0.031	0.167
SIM:LC	0.235	0.000	0.020	0.000

Less notable changes occurred in the average AEQ values for sublegal-sized and legal-sized fish. A comparison of average AEQ values obtained from PSC Chinook Model calibration 0907 for the recent time period (Table IV.2.5) against those from the base period (also presented in Table II.2.11) show there have been slight increases for troll-caught fish in both size categories. The AEQ values from NBC sport are the same for both time periods as these have been derived using values from the other two AABM sport fisheries. The ratio of the sublegal-sized troll AEQ value to the legal-sized troll value for converting SIMs to LCEs increased slightly between the two periods (Table IV.2.5).

Table IV.2.5. Average AEQ values for legal- and sublegal-sized fish and the LCE_f (= ratio of average AEQ_{SL} to average AEQ_L) by gear sector for the NBC AABM fishery, 1985-1995 and 1999-2008.

AEQ Statistic	1985-1995		1999-2008	
	Troll	Sport	Troll	Sport
$AEQ_{f,L}$	0.891	0.872	0.893	0.872
$AEQ_{f,SL}$	0.685	0.620	0.689	0.620
LCE_f	0.769	0.711	0.771	0.711

From the average AEQ values, TCE scalars were computed for use in converting sport-caught fish to troll landed catch equivalents for the recent period (Table IV.2.6). A comparison with the TCE scalar computed from data from the base period (see also Table II.2.13) showed a slight decrease.

Table IV.2.6. Scalars for converting gear-specific LCEs to TCEs for the NBC AABM fishery for the 1985-1995 base period and the 1999-2008 current period.

Gear Sector	Scalar for conversion to TCE	
	1985-1995	1999-2008
Troll	1.000	1.000
Sport	0.979	0.976

TM was calculated at each AI and LC in Table 1 using the ratios and scalars derived for the 1999-2008 period. The series of calculations was described in detail in sections II.1and III.4 for each of the AABM fisheries and in the preceding section for the SEAK AABM. The description will not be repeated here but the results of the calculations for each gear sector and the total TM in TCEs are presented in Appendix D. Principally due to the overall reduction in IM:LC ratios, TM based on recent data is considerably less than that based on data from the base period. The relative decrease is a constant 10.4% less at all AIs. The fixed change is a consequence of assuming the same allocation between the sport and troll sectors (20% and 80%, respectively, in the total LC) for both TM regimes.

The second approach to investigating effects of temporal changes in the IM rates and scalars involved computing potential nominal LC given the TM at each AI as presented in Table II.2.14. This exercise also incorporated the preseason management allocation to the sport sector of 40,000 Chinook salmon. LC was obtained at each AI in Table 1 using EXCEL Solver which iteratively adjusted the total nominal LC until all categories of IM and LC from both sectors equaled the total TM specified in TCEs. These estimates of potential LC under the TM regime, as well as LC under the current LC regime and the two TM series, one computed from 1985-1995 data and one computed form 1999-2008 data, are all shown in Figure IV.2.4. At all AIs, LC under the LC regime is the lowest series while TM derived from base period rates is the highest. Surprisingly, LC under a TM regime based on 1999-2008 rates would exceed the TM computed from these same rates (but based on the LC at each AI in the current Table 1). A simpler comparison of LC at three AI values only, low, average and high, shows that the percentage increase under the TM regime increases as the AI increases. The increase at a relatively high AI level of 1.80 could be as much as 13% assuming perfect information and management. Even at the average AI observed from 1999-2008, the increase in LC under the TM regime could exceed 12%.

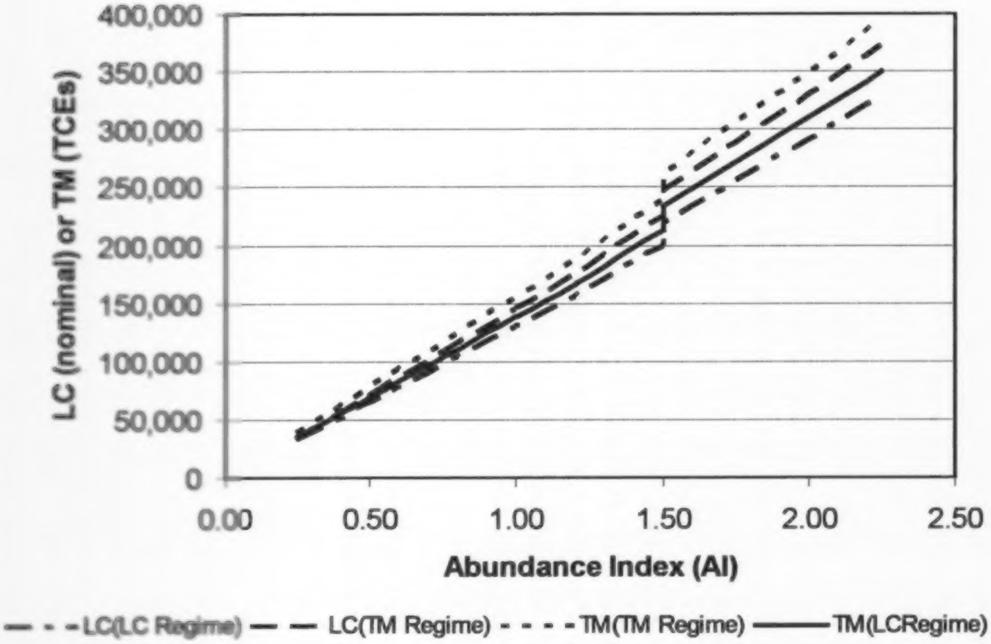

Figure IV.2.4. LC in nominal number of Chinook salmon and TM in TCEs over the full range of AIs under the current LC regime and projected under a TM regime for the NBC AABM fishery.

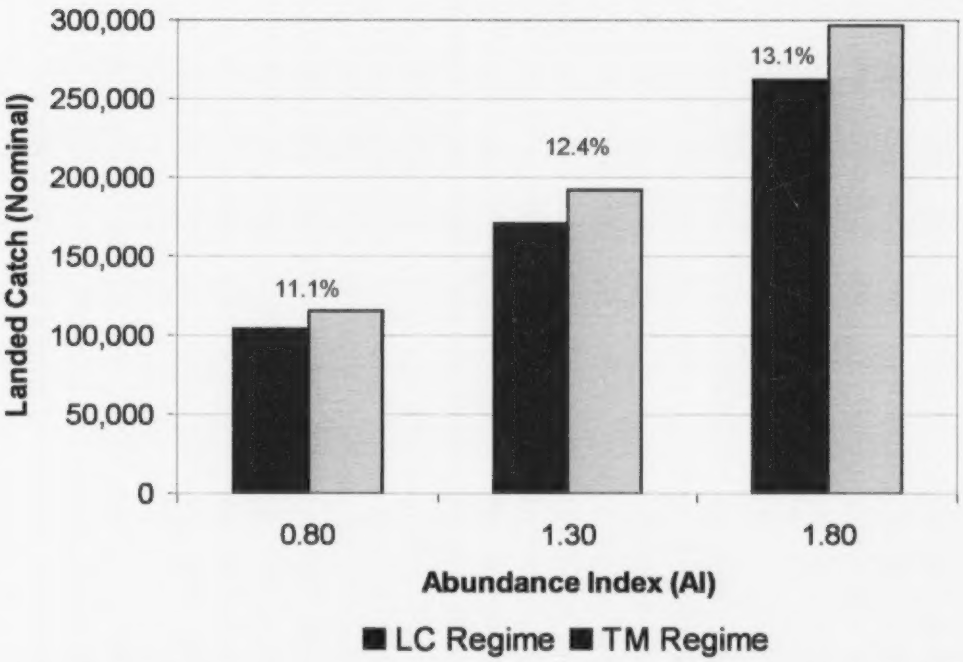

Figure IV.2.5. Potential LC in nominal numbers of Chinook salmon at three AI levels for the NBC AABM fishery under a TM regime and the current LC regime. Values above the bars are the percentage increases in LC under the TM regime.

IV.2.C WCVI AABM Fishery

The effects of temporal changes in IM rates and scalars were investigated for the WCVI AABM fishery using the same approach as used for the NBC AABM fishery. The same sequence of tables and figures is presented and consequently, description of the procedures is minimized. As before, the first step involved the development and presentation of the rates and scalars from the 1999-2008 period necessary for the computation of TM reflecting conditions under which the LC regime has operated in recent years. The derivation of the average IM ratios was described in Sections II.1.C (1985-1995 data, see Table II.1.28 and Table II.1.32) and in III.4.C (1999-2008, see Table III.4.19 and Table III.4.22) and the values are presented together here in Table IV.2.7. The sport SIM:LC ratio was the only IM ratio to show an increase from the earlier period to the more recent period (19.6%). The LIM:LC ratio for both the troll and sport sectors showed noticeable but modest declines (18.4% and 5.5%, respectively). The decline in the troll SIM:LC ratio was much larger at 86.4%. The large decrease in the troll SIM:LC ratio is due to a decrease in the legal minimum size limit (67 cm to 55 cm) which occurred in October of 1998. It is also due to the permanent closure of certain areas where encounters with small fish are known to be high. Explanations for changes to other ratios are not so obvious.

Table IV.2.7. Average ratios of LIM:LC and SIM:LC for WCVI troll and sport for the 1985-1995 base period and the 1999-2008 recent period.

Ratio Statistic	1985-1995		1999-2008	
	Troll	Sport	Troll	Sport
LIM:LC	0.026	0.145	0.021	0.137
SIM:LC	0.361	0.046	0.049	0.055

The average AEQ value for sublegal-sized fish released in the troll fishery decreased substantially (14.0%) as would be expected with the decrease in the size limit Table IV.2.8). The average AEQ value for legal-sized fish declined but only marginally (1.0%). There was essentially no change in the average AEQ values for either size category of fish in the sport fishery. The ratio of the average sublegal-sized AEQ to the average legal-sized AEQ, the scalar for converting SIMs to LCEs declined considerably for the troll sector (13.2%) and remained basically unchanged for the sport sector.

Table IV.2.8. Average AEQ values for legal- and sublegal-sized fish and the LCE_f (= ratio of average AEQ_{SL} to average AEQ_L) by gear sector for the WCVI AABM fishery, 1985-1995 and 1999-2008.

AEQ Statistic	1985-1995		1999-2008	
	Troll	Sport	Troll	Sport
AEQ_{fL}	0.904	0.895	0.895	0.899
AEQ_{fSL}	0.695	0.590	0.597	0.588
LCE_f	0.768	0.659	0.667	0.653

Finally, a comparison of the TCE scalar, computed as a ratio of the legal-sized AEQ value from the sport fishery to the legal-sized AEQ value from the troll fishery, showed an increase between the two time periods (Table IV.2.9). The higher legal-sized AEQ from the sport catch sector compared to the troll catch is a bit challenging to explain but may be an indication of sorting for larger fish by the sport sector.

Table IV.2.9. Scalars for converting gear-specific LCEs to TCEs for the WCVI AABM fishery for the 1985-1995 base period and the 1999-2008 current period.

Gear Sector	Scalar for conversion to TCE	
	1985-1995	1999-2008
Troll	1.000	1.000
Sport	0.990	1.004

Using the rates and scalars from 1999-2008, TM was calculated at each AI and LC in Table 1. The series of values are presented in Appendix D. TM based on recent data is considerably less (15.4% at all AIs) relative to that based on data from the base period. This is due mainly to the considerable decrease in the troll SIM:LC ratio (from 0.361 to 0.049) and in the reduction in the scalar for converting troll SIMs to LCEs (from 0.768 to 0.667). The fixed difference at all AIs is a consequence of assuming the same allocation between the sport and troll sectors (20% and 80%, respectively, in the total LC) for both TM regimes.

Next, potential LC was computed using the 1999-2008 IM ratios and scalars under the version of TM constructed for Table 1. The actual preseason allocation used by CDFO fishery management for the WCVI sport fishery (50,000 Chinook) was also incorporated into the calculation. The calculation procedure used EXCEL Solver to iteratively adjust total nominal LC until all categories of IM and LC from both sectors equaled the total TM specified in TCEs. These estimates of potential LC under the TM regime, as well as LC under the current LC regime and the two TM series (one computed from 1985-1995 data and one computed from 1999-2008 data), are all shown in Figure IV.2.6. The general pattern in the relationship between the two LC data series and the two TM data series with the AI is similar to that found for the NBC AABM fishery (see Figure IV.2.4). Again, LC under the LC regime and TM derived from base period rates bracket the other two data series in magnitude. LC under a TM regime based on 1999-2008 rates would exceed the TM computed from these same rates (but based on the LC at each AI in the current Table 1). It also exceeds LC under the LC regime by a considerable amount which increases as the AI increases. This effect is more easily discerned in Figure IV.2.7 which shows both LCs at a low, average and high AI value for this AABM fishery. The increase in potential LC under a TM regime (based on 1985-1995 rates) at an AI of 0.75, could be as much as 16% assuming perfect information and management. This AI is the average preseason value observed from 1999-2008. The relative increase in potential LC would increase further at higher AIs.

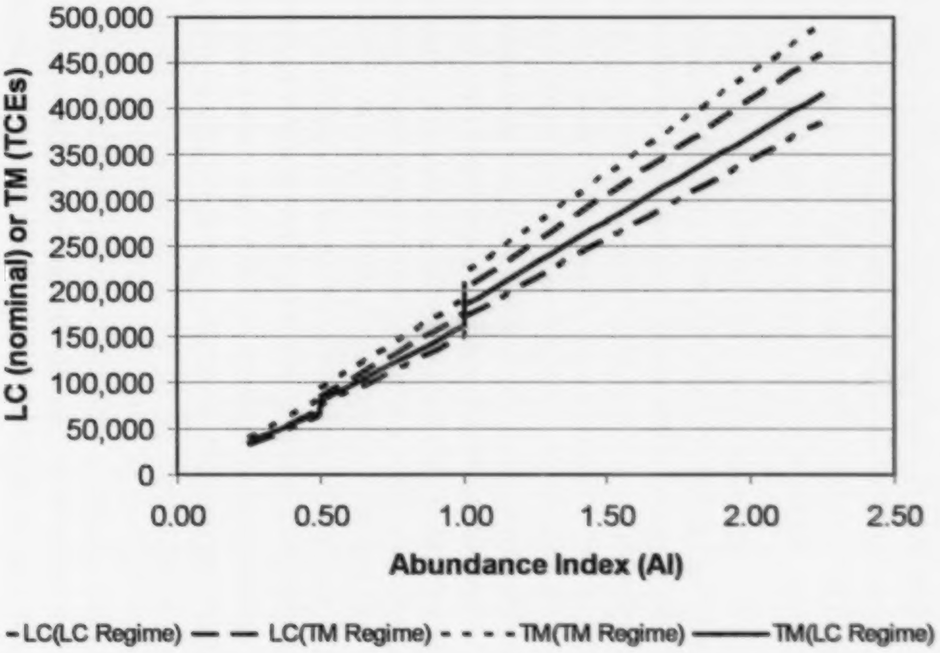

Figure IV.2.6. LC in nominal number of Chinook salmon and TM in TCEs over the full range of AIs under the current LC regime and projected under a TM regime for the WCVI AABM fishery.

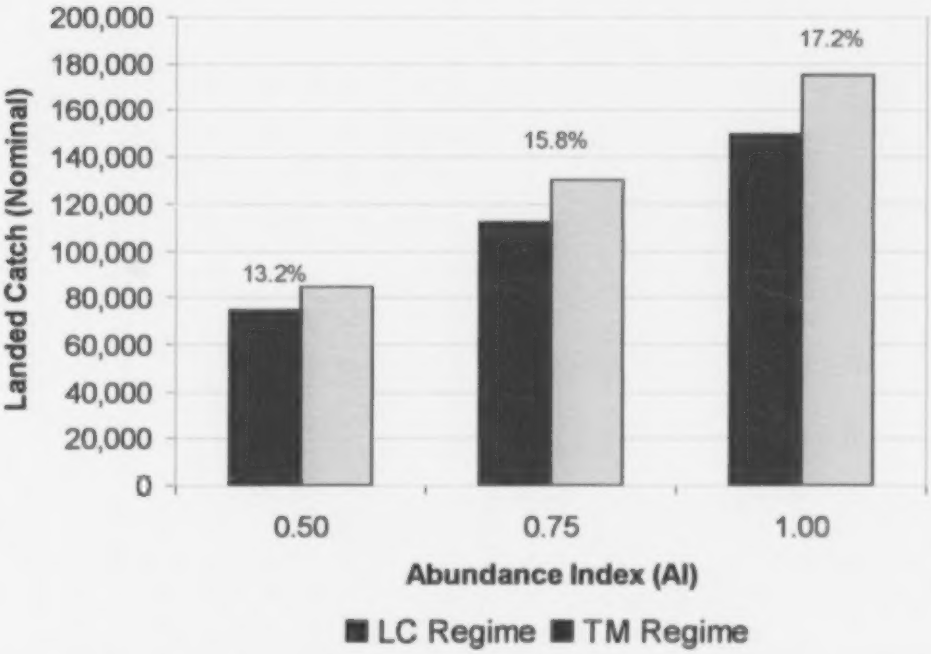

Figure IV.2.7. LC in nominal numbers of Chinook salmon at three AI levels for the WCVI AABM fishery under a TM regime and the current LC regime. Values above the bars are the percentage increases in potential LC under the TM regime.

V CAVEATS AND FUTURE REFINEMENTS FOR TM MANAGEMENT

V.1 PSC CHINOOK MODEL ISSUES IDENTIFIED DURING THE TMWG INVESTIGATIONS

During the course of investigating the implications of changing from a LC regime to a TM regime for Chinook salmon, the CTC identified a number of issues with the representation of the IM associated with the landed catch estimates from the PSC Chinook Model. For example, the current Model generates biased estimates of SIM in the AABM retention troll fisheries (Figure V.1.1 and Figure V.1.2). The magnitude of the bias has increased dramatically since the start of the abundance-based management under the 1999 Agreement; the current Model does not account for the large temporal decreases in IM in the commercial gear sectors under recent management conditions. The unrealistic Model estimates of SIM affect the computation of the time series of AIs used to set catch limits for AABM fisheries under either LC or TM management, as well as the AEQ values used to translate the current Table 1 LC limits TM limits. A variety of Model improvements are needed (some critically) to provide more reliable information for management applications.

Following are the PSC Chinook Model improvements, in no particular order, that have been identified by TMWG:

1. Replacement of the current fishery-specific PNVs with stock-, age- and fishery-specific PNVs for improved stock and age composition estimates in fisheries. This is currently being done as part of a Model coding contract funded with the Model Improvement funds held at the PSC office.
2. Correction of the Model's estimation bias of SIM in retention troll fisheries. This involves developing the capability to incorporate external estimates of SIM in retention fisheries and LIM in sport fisheries, and tuning the Model output to match external estimates where these are available.
3. Separation of the SEAK seine and gill net fisheries in the model. This is currently being addressed by the AWG.
4. Separation of Fishery 19 (North/Central BC sport) into NBC sport (AABM), other NBC sport (ISBM), and CBC sport (ISBM). This is currently being addressed by the AWG.
5. Separation of Fishery 20 (WCVI Sport) into WCVI AABM Sport (outside) and WCVI ISBM Sport (inside). This is currently being addressed by the AWG.
6. Separately report LIM drop-offs from "shakers" so that shakers estimates during Chinook retention periods are comprised entirely of SIMs for all fisheries. This change was implemented in 2009 beginning with Model calibration 0907.
7. Creation of a SEAK hatchery model stock(s) to more accurately represent the TM mortality impacts in the SEAK AABM fishery since the "treaty" catch of Chinook in SEAK does not include the Alaska hatchery add-on fish but does include a portion of the Alaska hatchery Chinook salmon present in the fishery (the base period average contribution plus a risk adjustment amount). This change is currently being addressed by the AWG.
8. Develop methodology and procedures for incorporation of stock composition estimates from new external sources (e.g., GSI studies). Estimates of the stock composition of sublegal-sizes fish derived independently from the stock composition of legal-sized fish could show distinct fishery-specific differences and would more accurately represent stocks and their abundance under TM management. Future work has been identified for the longer-term.
9. Decomposition of some of the existing Model stock groups, which may consist of multiple life history types, into smaller and better represented components. Work has been initiated by the AWG.
10. Addition of new fisheries, e.g., stock-specific terminal fisheries. Work by the AWG is underway.

Examination of the effects of the above modifications to results generated by the Chinook Model will occur. Changes to the time series of data generated by the Chinook Model are to be expected. Changes are also to be expected on the time series of AIs for each AABM fishery.

Figure V.1.1. Percent difference between PSC Chinook Model (calibration 0907) and observed (or empirically derived) SIM in nominal fish in AABM troll fisheries for the 1985-1995 base period. Model SIM estimates have been adjusted to actual nominal estimates.

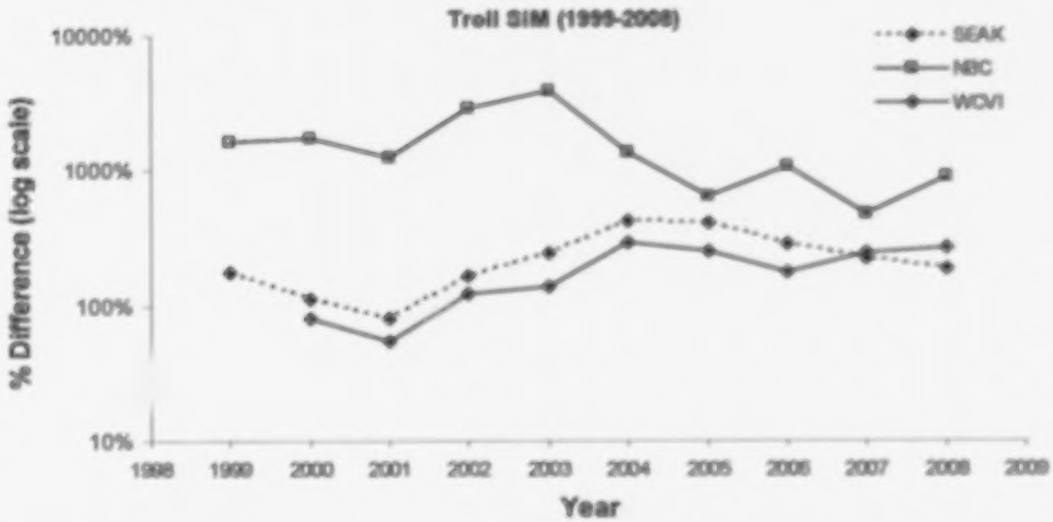

Figure V.1.2. Percent difference between PSC Chinook Model (calibration 0907) and observed (or empirically derived) SIM in nominal fish in AABM troll fisheries from 1999-2008. Note that the y-axis is a logarithmic scale. Model SIM estimates have been adjusted to actual nominal estimates. Percent difference for year 1999 for the WCVI fishery is not depicted in the figure because it is negative (-26%).

V.2 EFFECTS OF MODEL IMPROVEMENTS ON TM ASSESSMENTS

Improvements or changes to the underlying data in the Chinook Model or to the Model algorithms could have a profound effect on parameters used to generate Table 1 for both LC and TM regimes. Model changes could result in the changes in the estimates of AEQs as well as the magnitude of the yearly AI values. The AI values are fundamental to the underlying relationship of Table 1 in the Agreement that defines LC (and derivatively, TM) for AABM fisheries.

Estimates of AEQs are used to structure the scalars for each AABM fishery for calculating LCEs for SIMs for a gear type, and between gear types for LC and LIMs. Potential changes to the Model include an effort currently underway to improve the algorithm used in the Model to estimate the stock and age specific PNVs in each fishery based on stock specific growth functions. This is a completely different method than is currently employed in the Model. The current PNV estimates used in the Model are based on empirical estimates of Chinook size at age in each fishery derived from historical CWT data, and are not stock specific, but fishery specific for all stocks. This change in the way PNVs are calculated will most likely result in changes to the estimated stock and age compositions of the fishery catches in the Model. These composition changes will then affect the average AEQs that are calculated for the fisheries. The changes to the stock and age compositions of the fishery catches will also affect the estimated cohort sizes for the stocks which will in turn have an effect on the yearly AI values for the AABM fisheries. This change to estimation of the PNVs is merely one example of how changes in the Model can affect the estimates of the AEQs and the yearly AI values. The adjustment of the PNVs to correct the current model bias in estimating SIMs in retention troll fisheries (as demonstrated in Figure V.1.1 and Figure V.1.2) will also affect the estimates of AEQs and AIs.

Another factor that can influence the time series of AI values is the PNV reference year chosen when calculating the AIs. Since the vulnerable cohort sizes of the stocks and ages in a fishery depend upon the size limit and since the size limit can change, a reference PNV year corresponding to a particular size limit is chosen to use in the calculation of the entire time series of AIs. This is done for consistency in the calculation of the AI to ensure that changes in abundance are not confounded with changes in vulnerable cohort sizes due to a change in the size limit. Any data or algorithm changes that result in changes to the estimated stock and age compositions in the fisheries or affect the overall magnitude of the catch in the fisheries will have an effect on these Model statistics. Other changes to the Model data or algorithms that could affect these values include modifications to the stock recruitment parameters, changes to the terminal run or escapement data, addition of new stocks to the Model, aging stocks based on their life history as opposed to traditional anniversary dates. This is by no means an exhaustive list but is illustrative of the types of changes to the Model that could produce changes to the estimates of AEQs as well as the magnitude of the yearly AIs.

Changes to the Model that modify the AEQs and the AIs would have an effect on the current LC regime as identified in Table 1 of the 2008 PST. There would also be effects on the proposed TM regime and modified Table 1 that defines the relationships between the AIs and levels of TM in the AABM fisheries. Changes to the historical AI time series would change the historical relationships between the AIs and the landed catches. This would affect the proportionality constants that underlie the Table 1 relationships between AIs, catches and target harvest rates. The current LC Table 1 would most likely need to be modified depending on the magnitude of the changes to the

historical relationships. In addition, changes to the AEQ values would affect the LCE scalars which in turn would affect the TM estimates. Therefore, changes to the Model could also affect the values in the proposed TM version of Table 1 due to changes in both the historical AIs and the historical estimates of TM.

One of the primary objectives in improving the estimation of IM, either through improvement in the estimation algorithms when observed data are unavailable or through incorporation of observed encounter estimates, is improved estimation of the stock- and age-specific cohort abundances. The cohort sizes generated by the Chinook Model determine the annual AI values for each AABM fishery and if the cohort sizes are biased, the AI values will be too. AI values which are either regularly too high or too low will have unintended consequences. In the first case, higher than intended harvest levels will result in negative impacts on stocks. In the latter case, lower than intended harvest levels will result in foregone fishing opportunity. Any substantial modification to the Chinook Model will have ripple effects in the relationships and parameter values underlying the relationship between landed catch (or TM) and the AI in Table 1 which will require investigation. The modifications to the Chinook Model and possible changes to the relationships underlying Table 1 are equally imperative under the current LC regime and a future TM regime.

V.3 PROBABILITY OF RECRUITMENT METHOD FOR ESTIMATING LANDED CATCH EQUIVALENTS

AEQs represent the probability that a fish of a given stock and age would survive to reach its terminal area *in the absence of fishing* in the current and all future years. As such, AEQs do not consider effects of retention regulations on catch or incidental fishing mortality.

Instead of AEQs, the probability of recruitment (PR) method could be employed to compute LCEs in a way that incorporates effects of differences in size dependent retention regulations and the time required for fish that are sublegal in one fishery to reach legal size in a subsequent fishery. Different types of PR scalars can be computed to convert mortalities of sublegal- and legal-sized fish between fisheries that operate under different size-dependent retention restrictions (e.g., different minimum size limits).

Both AEQs and PRs depend on stock and age specific maturation rates. However, PRs also depend on stock-age specific PNVs (the proportion of a given stock-age cohort that is not-vulnerable to the gear). PNVs are key parameters in estimating the number of shakers and resulting incidental mortalities in a given fishery. Currently, the PNVs in the PSC Chinook Model are age-and fishery specific (see Section V.2.). This leads to several complications. First, stock-specific differences in the size of fish at age are ignored. Second, because age-specific PNVs are fishery rather than stock dependent, PNVs of fish from the same stock and age can differ between fisheries even when retention size limits are identical. Third, current age 2 PNV values used for both the PSC Chinook Model and the CTC's Exploitation Rate Analysis are not based on biological growth, but rather are derived from the assumption that differences between PSC Chinook Model estimates of sublegal shakers and the numbers of shakers observed by fishery sampling programs are due to the proportion of age 2 fish that are vulnerable to the gear. A scalar is employed to alter age 2 PNVs so that PSC Chinook Model estimates of sublegal shakers fit reported shaker observations during the Model base period (1979-1982). This assumption can lead to a situation where the PNVs for age 2 fish of a given stock and size are smaller than those for age 3 fish of the same stock. The Model Improvement Workgroup has identified the need to revise the model to use stock-age-fishery

specific PNVs. When stock-age PNVs are employed, cohort analyses will be affected because of differences in incidental mortality estimates. Further, by replacing the current fishery-age specific PNVs in the PSC Chinook Model with stock-age specific PNVs, the stock-age compositions of both landed catch and incidental mortalities would change, affecting average AEQ values produced by the PSC Chinook Model. Once stock-specific PNVs are incorporated into the PSC Chinook Model, the PR method of calculating LCEs can be evaluated to determine if it represents an improvement to the AEQ-based methodology. The PR method is described in detail in Appendix E.

V.4 SIZE LIMIT CHANGES

Changes to the minimum size limit in a fishery affect the ratio of sublegal incidental mortality to landed catch (SIM:LC). If the minimum size limit is raised, the SIM:LC ratio will increase because a larger fraction of encounters will be below the minimum size limit.

Higher SIM:LC occurred when the minimum size limits were 67 cm than when lower size limits were used for the WCVI troll fishery (Figure V.4.1), but this pattern was also evident for SEAK and NBC AABM troll fisheries where size limits did not change (Figure V.4.2). Other characteristics of fisheries, such as the extent of CNR periods, ceiling- or aggregated abundance-based management, and spatial-temporal fishing patterns varied among years, making it difficult to isolate the effect of minimum size limits on the SIM:LC for the AABM troll fisheries.

The influence of troll fishery location (i.e. SEAK, NBC, or WCVI), management regime (i.e. ceiling- or abundance-based), and size limit on SIM:LC were investigated using GLM ANOVA. The full factorial model was reduced to only the factor and intercept because statistical tests indicated factor interactions were non-significant (all $P \geq 0.081$), and fishery location, management regime, and size limit were significant factors (all $P \leq 0.001$). The residuals from the model had a mean of 0, were normally distributed (Kolmogorov-Smirnov $Z = 1.043$, $P = 0.227$), and formed a horizontal band when plotted against the predicted values with no signs of heteroscedasticity. Fishery location had the largest effect on SIM:LC, as indicated by the model coefficient (Table V.4.1), and the coefficient for NBC was not significantly different than the one for SEAK, which indicated a difference between the higher SIM:LC for the WCVI than the northern fishery locations. Fishery management regime resulted in higher SIM:LC under ceiling-based management than abundance-based management. The SIM:LC increased significantly as the minimum size limit was increased, and the influence of the size limit on SIM:LC depended on the magnitude of the change in the size limit. The analysis indicates that the SIM:LC was reduced substantially by lowering the size limit from 67 cm to 55 cm for the WCVI troll in 1999-2008 (Figure V.4.2).

Table V.4.1. Summary coefficients for GLM[1] to predict SIM:LC from fishery location (1=WCVI, 0=SEAK or NBC), fishery management regime (1=abundance-based, 0=ceiling-based), and size limit (cm).

Parameter	Coefficient	Standard Error	t-value	P-value
Fishery Location (FL)	0.164	0.030	5.528	<0.001
Fishery Management Regime (FMR)	-0.176	0.021	-8.544	<0.001
Size Limit (SL)	0.013	0.003	4.492	<0.001
Intercept	-0.631	0.198	-3.184	0.002

[1] SIM:LC = 0.164*FL-0.176*FMR+0.013*SL-0.631

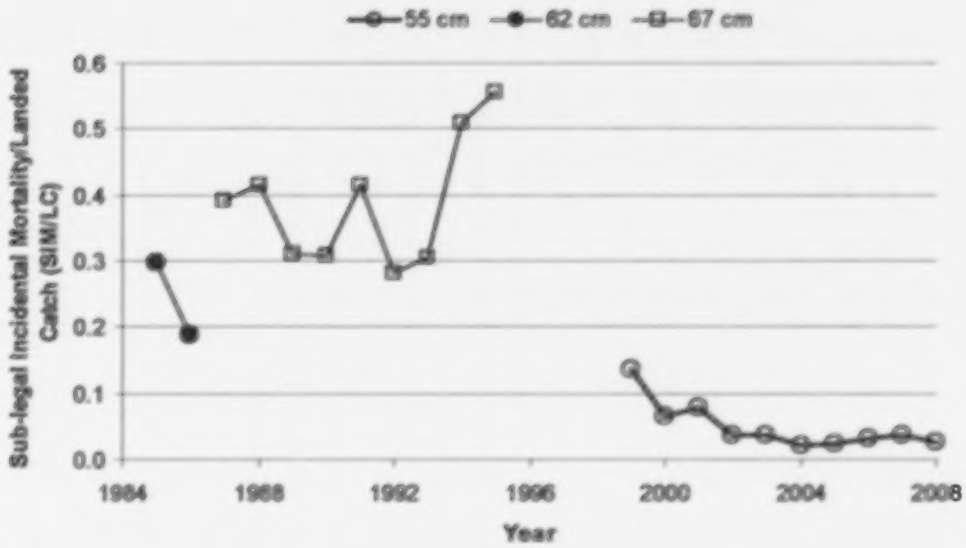

Figure V.4.1. Ratio of SIM to LC by year and minimum size limit in the WCVI troll fishery based on incidental mortality data presented in Figure III.6.6 and landed catch presented in Figure III.5.18.

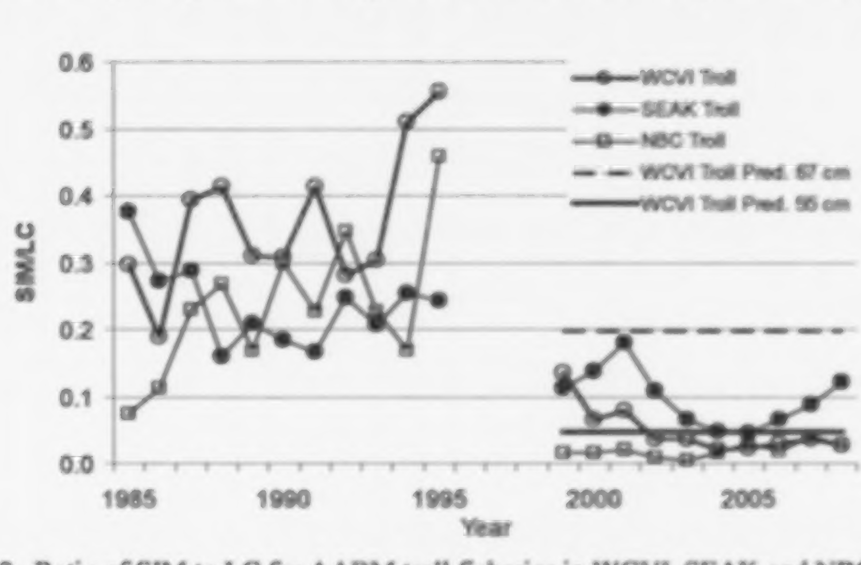

Figure V.4.2. Ratio of SIM to LC for AABM troll fisheries in WCVI, SEAK and NBC based on incidental mortality data presented in Section III.5 and predicted SIM:LC for the WCVI troll fishery for 55 cm and 67 cm size limits using the GLM coefficients in Table V.4.1.

To further examine the influence of variations in size limits on SIM:LC, the length-frequency distribution for 6,585 Chinook salmon measured by chartered vessels from 1987-1990 in the WCVI troll fishery (Olson et al. 1988; Morris and Healey 1990; Waddell et al. 1992; C. McConnell, unpublished data) was used to calculate SIM:LC for potential size limits ranging from 50-75 cm FL. SIM was calculated for each 1 cm minimum size limit by multiplying the number of sublegal-sized fish by the release mortality and drop-off rates for the WCVI troll fishery (Table II.2.5), and LC

was the number of fish that exceeded the minimum size limit. The SIM:LC at each potential minimum size limit was standardized to the value of SIM (0.135) at a minimum size limit of 55 cm to characterize the relative increase in SIM:LC. Figure V.4.3 shows that SIM:LC increases relatively slowly as size limits increase from a 55 cm to 60 cm, with about a 70% increase in SIM:LC for a 60cm size limit relative to a 55 cm size limit. In comparison, SIM:LC increases 15 fold at a size limit of 75 cm vs. 55 cm and SIM:LC = 1.8. Although changes in size limits directly affect SIM:LC, size limit changes in the WCVI troll fishery may only account for a small amount of the variation in the SIM:LC time series because the same pattern was evident in SEAK and NBC AABM fisheries where size limits were not changed.

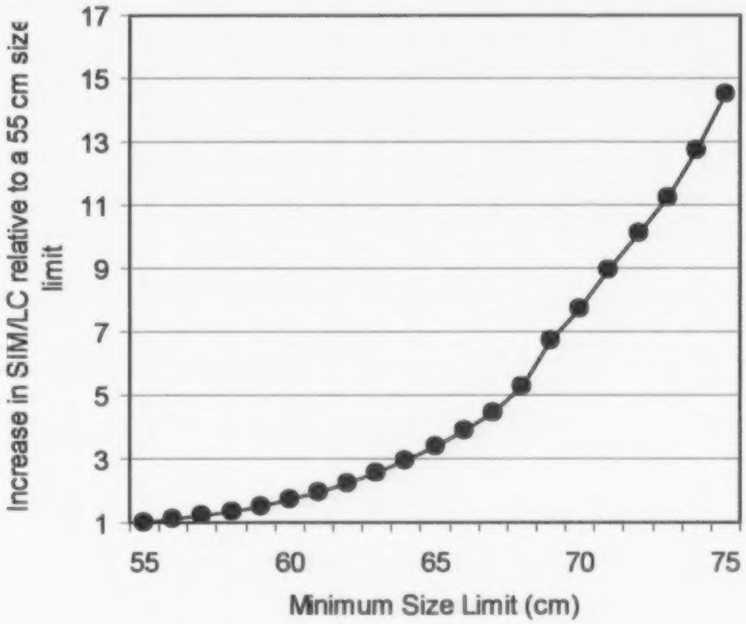

Figure V.4.3. Relative increase in the ratio of SIM to LC when potential minimum size limits were applied to the length-frequency distributions of 6,585 Chinook caught by chartered vessels in the WCVI troll fishery from 1987 to 1990.

Minimum size limits also influence the AEQ values used for the legal-sized and sublegal sized encounters, since lower minimum size limits can cause a larger proportion of the landed catch to consist of immature fish for pre-terminal fisheries. Changes in AEQs directly affect the computation of scalars used to calculate LCEs between SIMs and LIMs and between gear types (see Section III.7). AEQ values are involved in the calculation of LCEs and TCEs (see SectionII.2.A, which were used to generate the new Table 1 and are also used when mortalities are transferred between gears. When the size limit was raised from 62 cm to 67 cm in 1987 for the WCVI troll fishery, the AEQ values increased for sublegal-sized Chinook. However, a coincidental increase in the AEQs for legal-sized Chinook appears to have been fairly small relative the interannual variation in AEQ values for legal-sized Chinook during 1979-2008, which indicates that the AEQ for legal-sized Chinook is not sensitive to the minimum size limits ranging from 55 cm to 67cm (Figure V.4.4).

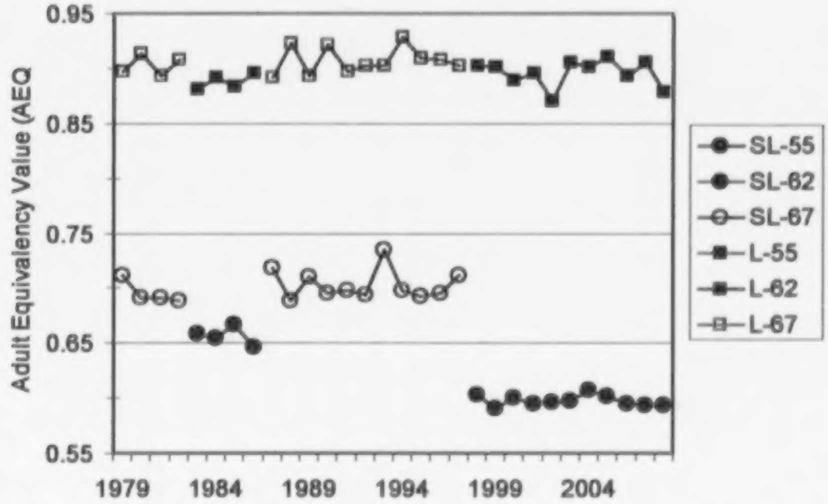

Figure V.4.4. PSC model estimates of AEQs for legal- and sublegal-sized Chinook for the WCVI troll fishery from 1979 to 2008. Squares represent AEQ values for legal (L) Chinook and circles represent sublegal (SL) Chinook. Size limits are represented by open, shaded, and closed symbols that correspond to 67 cm, 62 cm, and 55 cm, respectively.

V.5 SPATIAL OR TEMPORAL CHANGES IN FISHING PATTERNS

Information on the spatial and temporal variation of sublegal encounter rates in a fishery can be helpful for planning future fisheries with the objective of reducing encounters with sublegal fish, and ultimately reducing the SIM:LC. For the WCVI troll fishery, the encounter rates of sublegal-sized to legal-sized Chinook in Table V.5.1 indicates a pattern of higher sublegal encounter rates in south west Vancouver Island (SWVI) compared to north west Vancouver Island (NWVI) (Table V.5.1). In comparison, there appears to be much less temporal variation in the sublegal encounter rates based on the observations between April and November. For planning fisheries, one may assume spatial-temporal stability in the sublegal Chinook encounter rates. However, the actual sublegal encounter rates can vary due to factors such as the minimum size limit, relative abundance of stocks at different ages, and other fishery management restrictions such as species target and fishing gear used (e.g., hook size and lure type).

The SIM:LC ratio can also be reduced by avoiding areas with high concentrations of sublegal fish relative to landed catch. For example, SWVI has several bank areas (Figure V.5.2) where high concentrations of sublegal Chinook are regularly observed (Table V.4.1; Healey et al. 1985; Olsen et al. 1998., Morris and Healey 1990; Waddell et al. 1992). Parts of Swiftsure Bank, identified as conservation area F1, S and G in Figure V.5.3, were closed to salmon troll fishing to reduce encounters and mortalities of sublegal Chinook during 1985-1995 (Gillespie and Shardlow 1995; Shardlow et al. 1986, 1988, 1991; Ryall 1993; Ryall and Shardlow 1991, 1992). From 1998-2008 no commercial salmon troll fisheries occurred in management areas 21/121, with virtually zero Chinook salmon encountered (Velez-Espino et al. 2010). Also, at times other conservation area closures have been used for the SWVI banks to limit fishing rates on Chinook and other salmon species.

The observational data used to represent the sublegal encounter rates during the 1985-1995 base period for WCVI showed that the percentage of encounters that were sublegal-sized, when standardized to a 62 cm minimum size limit, had a stronger spatial than temporal pattern of variation among management areas and months in SWVI (Table V.5.1). Sublegal Chinook encounter rates were generally much higher in SWVI than in NWVI areas. During the 1985-1995 period, 5% of the average annual catch occurred in areas and months with at least an 80% sublegal encounter rate, 32% with sublegal encounter rates ranging 50%-80%, and 63% in with sublegal encounter rates were less than 50% (Table V.5.2). Then the fishery was mainly in the summer, but recently the fishery occurs mainly in the winter and spring to reduce encounters with interior Fraser coho and WCVI Chinook stocks. For comparison, changes to the spatial-temporal catch pattern during 1999-2008 resulted in lower average annual percentages of the catch occurring in areas and months with higher sublegal encounter rates; 1% occurred in months and areas with sublegal encounter rates exceeding 80%, 49% in months and areas with rates ranging from 50-80%, and 50% at rates less than 50%.

Table V.5.1. Percentage of Chinook salmon encounters that were sublegal-sized, based on a 62 cm or 67 cm FL minimum size limit, from observational data used to represent areas and months in the WCVI troll fishery for the 1985-1995 base period (from Table II.2.2). Dark shading identifies rates greater than 80%, whereas light shading identifies rates from 50%-80%. NA indicates area-months that were not sampled for encounter rates by Chinook size.

	Pacific Fishery Management Area[1]						
Month	21/121	23/123	24/121	25/125	26/126	27/127	Average
			62 cm FL Minimum Size Limit				
Apr	59%	50%	38%	38%	23%	NA	*42%*
May	68%	45%	28%	21%	25%	53%	*40%*
Jun	61%	50%	23%	15%	10%	21%	*30%*
Jul	87%	28%	38%	28%	42%	31%	*42%*
Aug	73%	32%	42%	31%	35%	11%	*37%*
Sep	82%	50%	77%	36%	16%	17%	*46%*
Oct	73%	61%	NA	NA	NA	NA	*67%*
Nov	63%	87%	NA	NA	NA	NA	*75%*
Average	*71%*	*50%*	*41%*	*28%*	*25%*	*27%*	*47%*
			67 cm FL Minimum Size Limit				
Apr	77%	67%	57%	42%	28%		*54%*
May	85%	67%	42%	30%	35%	53%	*52%*
Jun	81%	68%	36%	21%	24%	30%	*43%*
Jul	92%	43%	54%	40%	54%	41%	*54%*
Aug	88%	53%	71%	43%	42%	14%	*52%*
Sep	88%	71%	89%	42%	29%	22%	*57%*
Oct	77%	61%	NA	NA	NA	NA	*69%*
Nov	63%	87%	NA	NA	NA	NA	*75%*
Average	*81%*	*65%*	*58%*	*36%*	*35%*	*32%*	*51%*

[1]Figure V.5.1shows a map of these Pacific Fishery Management Areas.

Table V.5.2. Average annual percentage of the WCVI troll Chinook catch for each month and area during 1985-1995 and 1999-2008. The dark and light shading corresponds to the sublegal encounter rates identified by dark and light shading in Table V.5.1

Month	Pacific Fishery Management Area[1]						
	21/121	23/123	24/124	25/125	26/126	27/127	Total
1985-1995							
March	0%	0%	0%	0%	0%	0%	**0%**
April	0%	0%	0%	0%	0%	0%	**0%**
May	0%	1%	0%	0%	0%	0%	**2%**
June	0%	2%	0%	0%	0%	0%	**2%**
July	2%	26%	12%	5%	6%	10%	**61%**
Aug.	1%	7%	4%	2%	3%	7%	**24%**
Sep.	0%	2%	1%	1%	1%	4%	**9%**
Oct.	0%	0%	0%	0%	0%	0%	**1%**
Nov.	0%	0%	0%	0%	0%	0%	**0%**
Dec.	0%	0%	0%	0%	0%	0%	**0%**
Total	4%	38%	18%	8%	10%	21%	**100%**
1999-2008							
March	0%	1%	0%	0%	1%	0%	**2%**
April	0%	8%	0%	1%	8%	1%	**19%**
May	0%	14%	2%	1%	4%	2%	**22%**
June	0%	6%	1%	1%	1%	2%	**10%**
July	0%	0%	0%	0%	0%	0%	**0%**
Aug.	0%	0%	0%	0%	0%	0%	**1%**
Sep.	0%	7%	0%	1%	3%	3%	**15%**
Oct.	0%	12%	1%	5%	6%	1%	**25%**
Nov.	0%	1%	0%	0%	0%	0%	**1%**
Dec.	0%	2%	0%	0%	2%	0%	**5%**
Total	0%	50%	5%	10%	25%	10%	**100%**

[1]Figure V.5.1 shows a map of these Pacific Fishery Management Areas.

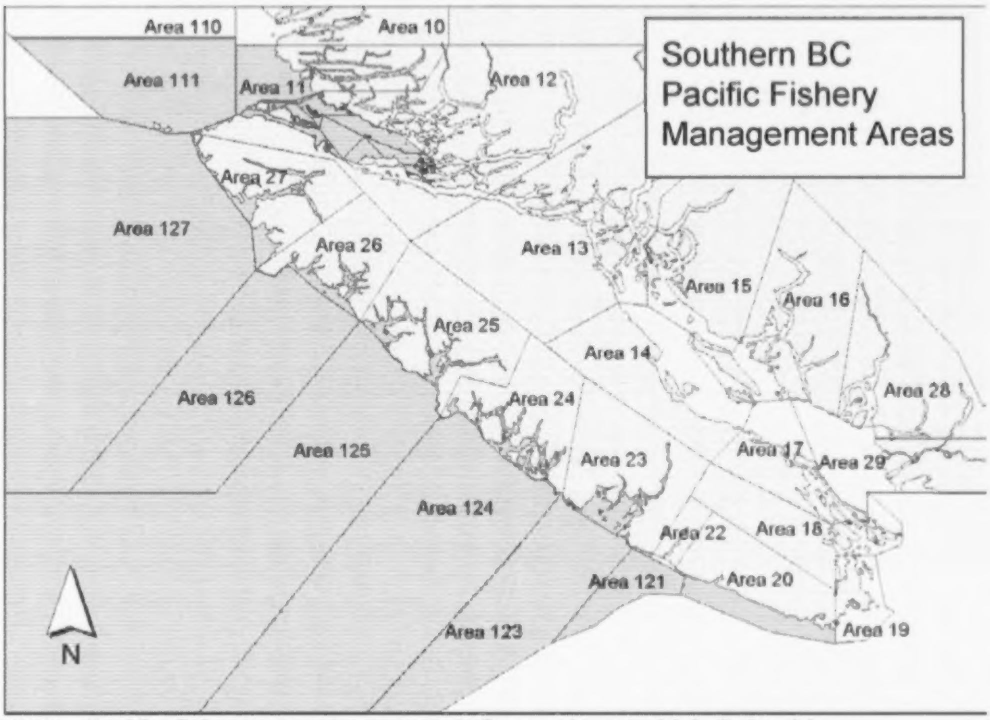

Figure V.5.1. Pacific fishery management areas for southern British Columbia.

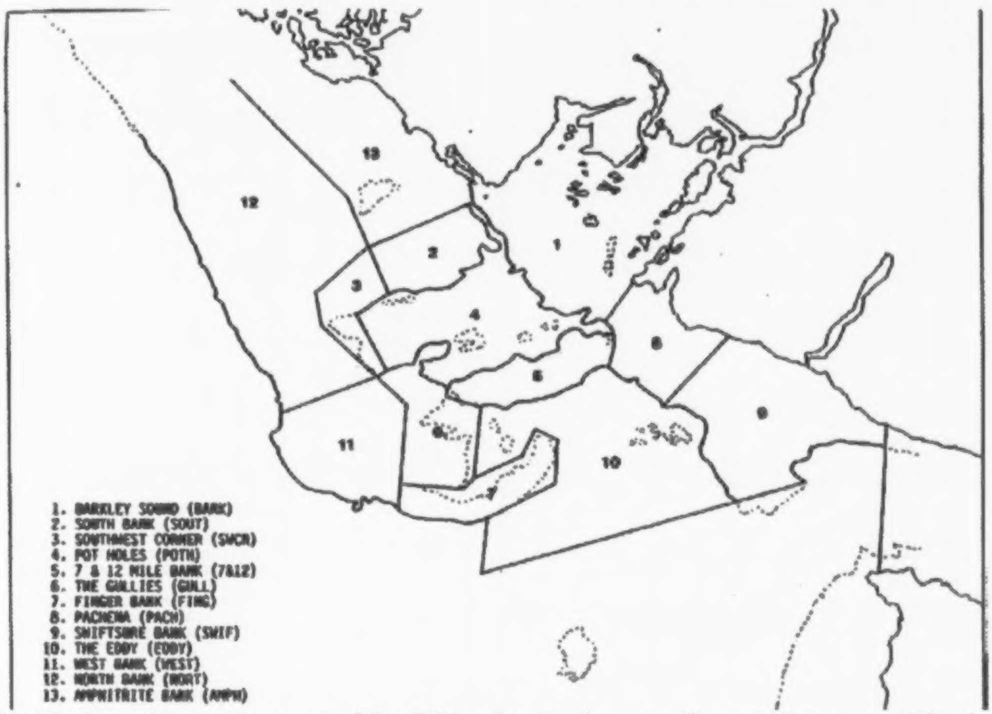

Figure V.5.2. Locations and names of the fishing banks along south west Vancouver Island surveyed by Olsen et al. (1988) and Waddell et al. (1992) for size composition and other biological characteristics of Chinook salmon.

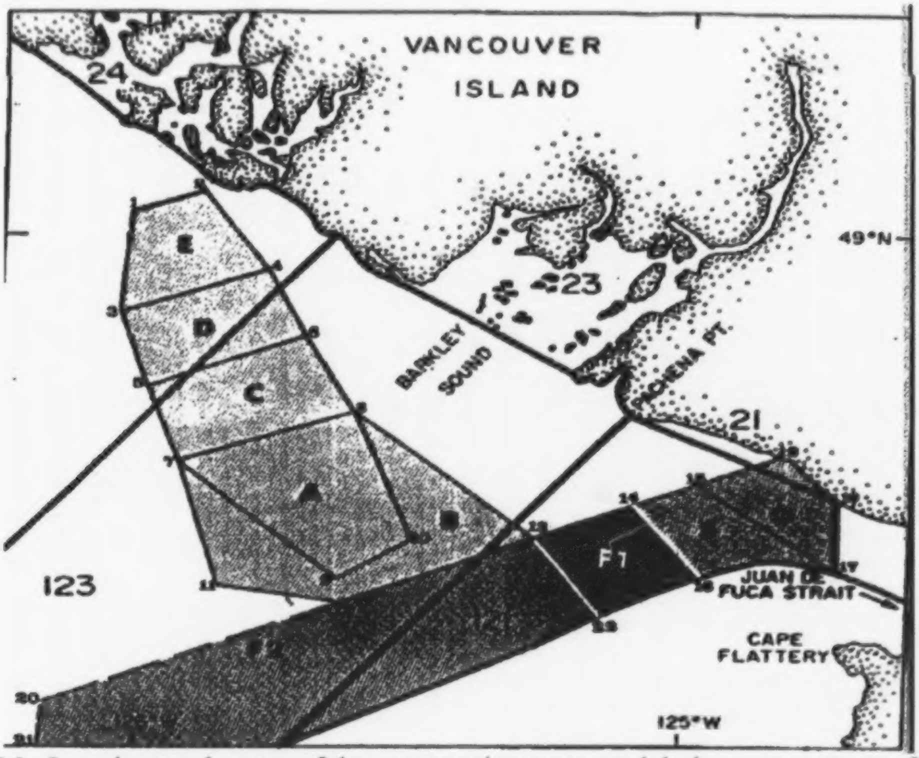

Figure V.5.3. Locations and names of the conservation areas used during management of salmon troll fisheries along southwest Vancouver Island during 1990 (Ryall and Shardlow 1992) for size composition and other biological characteristics of Chinook salmon.

Spatial and temporal closures have also contributed to reduced IM ratios in the SEAK troll fisheries (Sections III.5.A.1. and III.5.B.1). For instance, in 1994 the Alaska BOF adopted regulations that stated that the SEAK summer troll fishery would be managed for two openings. The first opening in July would target about 70%f of the summer quota. After the July fishery closed, areas of high Chinook abundance on the outer coast would be closed to decrease the number of Chinook encountered during CNR periods, and to slow down the Chinook catch during the second summer opening in August that was designed to harvest the remaining 30% of the summer quota. In addition, the allocation of the catch throughout the year can impact the IM ratios. Legal and sublegal Chinook encounter logbook data from the SEAK troll fishery is available for the entire 2004 and 2005 accounting years (Oct-Sep). The ratio of sublegal to legal encounters based on effort weighted time-area-gear sums from the logbooks was computed for both the winter (Oct-Apr) and summer (Jul-Sep) open troll periods in both years. The ratios can be seen in Table V.5.3. Two years of data do not provide a sufficient sample size for definitive conclusions. However, both years show that the ratio of sublegal to legal Chinook encounters is roughly twice as large in the winter open troll period as in the summer open troll period. This provides some evidence that the sublegal encounter rate is higher during the winter period than it is during the summer period. This conclusion agrees with anecdotal information provided by trollers and also makes intuitive sense. One would expect more legal sized Chinook during the summer fishing period, hence a lower sublegal to legal encounter ratio, since the fishery is occurring during the migration window for the mature Chinook spawners that are moving down the Pacific coast

Table V.5.3. Ratio of sublegal-sized to legal-sized Chinook encounters in the SEAK troll fishery during the winter and summer open fishing periods during 2004 and 2005.

	Year	
Period	2004	2005
Winter	0.19	0.24
Summer	0.13	0.10

In the NBC troll fishery, Canada has managed fishing impacts on Chinook stocks from WCVI since 1995. One of the main approaches has been to limit incidental mortalities by avoiding times and locations with high incidences of sublegal-sized Chinook. Further, objectives to protect Coho stocks from the upper Skeena River and interior Fraser River from 1998 to 2000 and more recently from the Central Coast have resulted in less troll fishing effort during CNR periods. Changes to NBC troll fisheries are well documented in (CTC 2006). Spatially, recent management actions have limited Chinook troll fisheries to Areas 1 and 2W off the northwest coast of Haida Gwaii (Queen Charlotte Islands). From 1999 to 2009 over 99% of the Chinook caught were from Areas 1 and 2W. These areas have lower encounters of sublegal-sized Chinook than troll fisheries in eastern Dixon Entrance and Hecate Strait (Areas 2E, and 3 to 10). Areas 1 and 2W accounted for 76% of Chinook LC from 1985 to 1995 and 51% from 1979 to 1982. Temporally, the majority of NBC troll fishing effort for Chinook has been limited to periods around June and July to maximize Chinook LC while avoiding fish from WCVI (Winther and Beacham 2006, 2009). Since 2004 an average of 87% of the NBC troll fishery Chinook LC has been caught in June and July compared with averages of 58% from 1985 to1995 and 55% from 1979 to 1982.

V.6 MARK SELECTIVE FISHERY CONSIDERATIONS FOR TM REGIMES

V.6.A Mark Selective Fisheries and Assessment of Fishery Impacts

Mark Selective Fisheries (MSF) employ retention limits to harvest adipose fin clipped ("marked") hatchery fish at a higher rate than unmarked fish. Because not all unmarked fish that are encountered die after being released, MSF are becoming increasingly employed to increase opportunities for harvesting hatchery fish while protecting wild fish in mixed-stock fisheries. Paragraph 5(a) of the 2008 Agreement most directly deals with MSF:

"mark-selective fisheries for Chinook will be conducted in a manner that reduces fishery impacts on natural spawning salmon relative to non-selective fishing alternatives"

For purposes of implementing the total mortality provisions of the 2008 Agreement for AABM fisheries, incidental mortalities in MSF depends on the following factors: (1) the proportion of marked fish encountered in the fishery (mark rate), which may be retained; (2) the intensity of the MSF (the proportion of marked fish in the population that may be harvested); (3) the mortality rates of the fish that are encountered; and, (4) the allowable incidental mortality on comingled unmarked stocks of interest.

Mark Rate. No historical observational data are available to provide information on incidental mortality to landed catch ratios (IM:LC) or the magnitude of various types of mortalities under

MSF. The mark rate and specific regulations would determine the proportion of fish that are landed that must be released. Thus, IM:LC increase as the mark rate decreases.

Intensity. The proportion of the marked population that is to be removed will determine the magnitude of incidental mortalities of fish that are released. As the intensity of MSF increases, the IM:LC would be expected to increase as the MSF progresses. IM will be underestimated by current models and methods employed by the CTC because of assumptions that mortalities from all sources are instantaneous and there is no consideration of mortalities due to multiple encounters of unmarked fish.

Mortality Rates. Under non-selective fishing (NSF), encountered fish that die from drop off and release comprise the vast majority of incidental mortalities. Two additional types of incidental mortalities are expected to result under MSF, mark retention and mark recognition error. These types of error would depend upon the effectiveness of education programs and the experience of fishers, and hence would be expected to change over time.

Allowable impacts on unmarked fish. Significant MSF would affect IM:LC in both the MSF itself during the conduct of the fishery and in "downstream" fisheries, whether mark selective or not. Downstream effects from reduced mark rates could include: (a) less flexibility in conducting subsequent fisheries and increased uncertainty in planning for ISBM fisheries; (b) fewer hatchery fish for producing jurisdictions to harvest or meet broodstock needs. Substantial MSF could increase the difficulty of conserving natural stocks. MSF impacts in AABM fisheries would not be constrained to protect individual stocks. Several provisions of the 2008 Agreement address potential concerns for impacts of MSF on the capacity to attain conservation objectives.

Under MSF, these four factors would combine to increase uncertainty and bias in estimates of incidental mortalities compared to NSF, which in turn could increase uncertainty in implementation of AABM regimes and assessment of ISBM obligations.

MSF of significant magnitude would require existing sampling programs, data reporting systems, planning and assessment models, and analytical tools to be modified. Monitoring and sampling programs would need to be capable of providing reliable estimates of legal and sublegal-sized marked and unmarked fish that are encountered, released, and retained to estimate total mortalities. Estimates of CWT recoveries in retained catch may be problematic unless catch sampling programs and expansion methods are designed to be consistent with the time/area/regulation strata employed for MSF. Further, the lack of coastwide electronic tag detection methods to detect CWTs will result in inconsistent recovery of double index tagged groups of marked and unmarked CWT'd fish increasing uncertainty over the impact of MSF.

Methods and tools to estimate total incidental mortalities or mortalities on individual stocks under the wide variety of regulations that could be employed to implement MSF are not available. Requirements for evaluation of MSF impacts depend on the magnitude, intensity (proportion of marked fish to be retained), the mixture of marked and unmarked, legal- and sublegal-sized fish, location, and duration of MSF.

Impacts of MSF on Chinook are cumulative. Because fisheries operate on a mixture of mature and immature fish from multiple broods, the magnitude of MSF in previous years will affect subsequent abundance and mark rates. By intent, MSF exert differential fishing mortalities on marked and

unmarked fish. Consequently, marked and unmarked fish from the same stock will be returning to terminal areas at different rates. Since methods for forecasting abundance for the Model commonly depend on sibling relationships and terminal returns, forecasting methods would need to be modified to provide separate forecasts for marked, marked+CWT, unmarked, and unmarked+CWT fish, which will in turn affect the abundance indices that drive the determination of allowable mortalities.

Where multiple MSF impact stocks of interest, no method has been developed to accurately allocate total exploitation rates on unmarked fish to individual MSF. This could increase uncertainty in assessing performance under ISBM obligations. Despite years of investigation by the Selective Fishery Evaluation Committee and the efforts of the CWT Expert Panel (2005), for Chinook salmon only methods to quantify differences in total exploitation rates on marked and unmarked DIT groups have been developed. Because of the potential difficulty of evaluating MSF impacts, paragraphs 5(b)-(c) of Annex IV, Chapter 3 of the 2008 Agreement addresses the need to coordinate with the Selective Fishery Evaluation Committee (SFEC) and report related statistics utilizing SFEC protocols.

V.6.B Implications of Mark Selective Fisheries under a TM Regime

Relationships underlying Table 1 are based upon the assumption of NSF. MSF result in the selective retention of marked hatchery fish above the minimum size limit and the observed age and stock composition will consist only of marked fish. The mortalities of the sublegal-sized and unmarked fish will be unknown and problematic to estimate. This type of fishery fundamentally changes fishing-related stock- and age-specific impacts compared to NSF by causing differential impacts on:

1. sublegal- and legal-sized Chinook;

2. marked and unmarked fish will have different relationships between LIMs, SIMs and LC depending on fishery regulations and the proportion of the exploited population that is marked;

3. information will not be available for the unmarked fish regarding stock and age structure as the mortalities will not be observed. Computation of the LCEs will be problematic because historical relationships of SIM:LC and LIM:LC will not be applicable.

Figure V.6.1 and Figure V.6.2 present a schematic of the categorization and generation of LIM and SIM in non-selective and mark-selective fisheries. The MSF increase the complexity of how these IM categories are generated, and result in directional changes to the magnitude of the IM (Figure V.6.2).

Non-Selective Fishing (Table 1 and 1999-2008 monitoring data)			
Legal-Sized Marked & Unmarked Fish	Drop Off LIM	LC	
Sublegal-Sized Marked and Unmarked Fish	Drop Off SIM		SIM
Same SIM:LC, LIM:LC relationships for marked and unmarked fish			

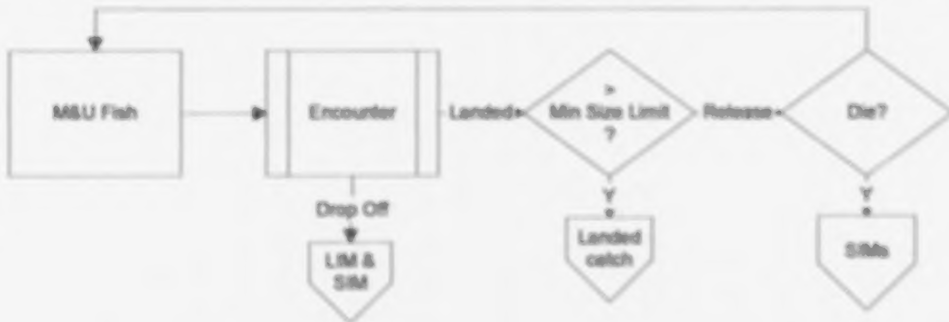

Figure V.6.1. Schematic of the categorization and generation of LIM and SIM for non-selective Chinook retention fisheries.

Mark-Selective Fishing (No historical data)			
Legal Sized Marked Fish	Increase in Drop Off LIM	Increase in LC	
Legal Sized Unmarked Fish	Increase in Drop Off LIM	Decrease in LC	Increase in LIM
SubLegal Sized Marked and Unmarked Fish	Increase in Drop Off SIM		Increase in SIM
Different LC, SIM:LC, LIM:LC relationships for marked and unmarked fish, depending on mark rate			

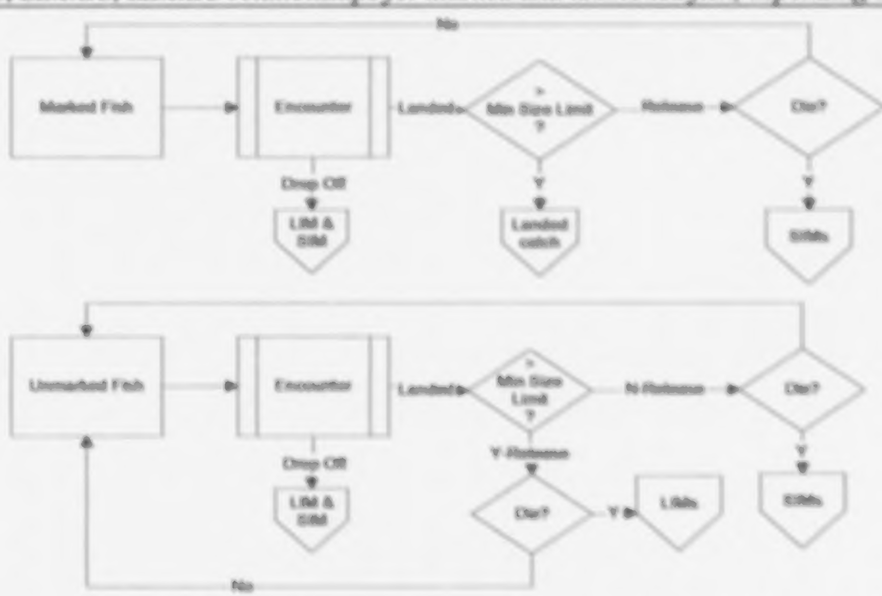

Figure V.6.2. Schematic of the categorization and generation of LIM and SIM for non-selective Chinook retention fisheries, and effects on the estimates of LIM and SIM.

V.7 A TOOL FOR IMPLEMENTATION

The computation of the TM Table 1 and the projection of TM limits are based on a number of parameters (e.g., AEQ's, SIM, LIM), which in turn are based on both model- generated data and observational and externally-estimated data. In this report, calculations for generating Table 1 and for estimating effects of TM limits on LC and TM were made with algorithms in EXCEL spreadsheets. The implementation of a TM regime will require preseason projections of TM and post-season evaluation, analysis of effects of changes to the CTC model, and simulations to evaluate changes in fishing regimes. These analyses can be greatly facilitated with the development of an implementation tool, a program for calculating LCEs and TM with a user interface for inputting the appropriate empirical or model-derived data. An outline of such a program is given in Appendix F. The TMWG recommends that the Model Improvement Group of the CTC consider development of this tool as part of its' work plan.

VI SUMMARY AND CONCLUSIONS

This report documents the CTC's extensive efforts to address the directives of the 2008 Agreement in relation to TM management in AABM fisheries prior to the 2011 season. The CTC has developed equivalency scalars to adjust LC and IM to LCEs. Because Table 1 is based principally on the relationship between the AI and troll LC, the CTC has expressed TM limits in terms of troll catch equivalents (TCEs). The CTC has compiled the best available empirically- derived estimates of IM:LC ratios for the 1985-1995 base period for IM defined in the 2008 Agreement. The CTC has applied these ratios and the equivalency scalars to construct a TM version of Table 1. The CTC also reviewed the ramifications of managing for TM limits in the AABM fisheries, the potential effects of using the proposed TM Table 1 on current levels of TM and LC, and considered caveats and possible future refinements to TM management. In this final section, the CTC highlights key outcomes and conclusions from the report.

VI.1 LCE APPROACH

The CTC considered several approaches to develop the scalars to translate LC and IM to LCEs, and determined that the AEQ-based approach is the best method currently feasible. This method is an improvement over the 1:1 value used in the LC regime, because it accounts for size and maturity differences by stock of both LC and IM in the AABM fisheries. However, because the AEQs are based on probability of survival in the absence of fishing, the AEQ approach may not adequately account for differing stock/age distribution harvested by different gear sectors or size limit differences between gear type sectors. The average AEQs may change with modifications to the CTC Model structure, such as with the use of stock-age specific PNVs. The CTC considers the AEQ approach the best currently feasible method to calculate LCEs to implement TM management by 2011. However, it also considers the TM Table 1 developed with the AEQ approach to be provisional, pending the feasibility of better methods. If TM management is implemented by the Commission, the CTC will need to continue to refine and revise the TM Table 1 as analytical approaches for calculating LCE scalars are developed and improved.

VI.2 TEMPORAL CHANGES IN IM:LC RATIOS

The TIM:LC ratios have declined between the 1985-1995 IM base period and the recent period managed under the 1999 Agreement (1999-2008) in all AABM commercial fisheries and WCVI sport. These declines are due to management changes that reduced IM. As a result, TIM in AABM fisheries is proportionally lower under current LC management than was the case during the IM base period.

VI.3 INCREASES IN TM AND LC UNDER A TM REGIME

Transitioning to the TM Table 1 based on 1985-1995 IM:LC ratios would potentially result in substantial increases in both TM and LC relative to the LC regime in place under the 2008 Agreement for 2009 and 2010. These potential increases are due to the declines in IM:LC ratios under current management practices relative to the 1985-1995 base period. Under TM management

as defined by the 2008 Agreement, the TM Table 1 limits would include the IM "savings" realized under current management, and thus would have a higher TM target than the TM currently occurring under LC management. If an AABM fishery attains these higher TM limits, and current rates of IM:LC are assumed, the LC would also be higher than what is currently allowed under the LC Table 1. The potential increases in LC are 18% for SEAK, 12% for NBC, and 16% for WCVI at long-term average AIs.

VI.4 EFFECTS OF CHANGES IN ALLOCATION BETWEEN GEAR SECTORS

Under a TM regime, the TM limits must be converted to LC for purposes of managing to gear sector allocations in an AABM fishery. The TM limits in Table 1 are based on specified sector allocations in Appendix B of the 2008 Agreement. However, the management objectives and allocations set by the Parties may differ from the allocations used in Appendix B. The CTC evaluated potential LC under a TM regime at different sector allocations over a range of AIs. The CTC found that the change in LC would be relatively small, ranging from 0-3% at average AIs for the AABM fisheries for the range of allocation scenarios examined. Additional scenarios could expand the range of potential change in LC but the effect of adjustments to allocations is much less than the effect of changes in IM:LC ratios from temporal and spatial adjustments to a fishery.

VI.5 INCREASED MANAGEMENT AND ASSESSMENT COMPLEXITY UNDER TM MANAGEMENT

Transitioning to a TM regime would increase the complexity of management and assessment for the respective management agencies and for the CTC. Managers would require gear-specific forecasts of IM to set management regulations to achieve the potential LC. The CTC would continue to report LC and estimates of IM for each gear type within the fishery, but would also need to translate these data into LCEs and TCEs as the measure of TM. The TCEs for each gear type and the sum of TCEs for each AABM fishery would be compared with the allowable TM associated with both preseason and post-season estimates of the AI from the revised TM Table 1.

VI.6 VALIDITY OF PROGRAMS FOR DIRECT ESTIMATION OF IM

Under TM management, agencies would need to validate encounter estimates from user-reported data (e.g., log books, creel census, mail-out surveys) with direct and independent observations to detect and correct under-reporting biases. Costs of such programs are likely to be substantial. Introduction of new monitoring technology could reduce costs but will require consideration of how data are collected and reported. Under LC management, released encounters were reported in the annual reports on catch and escapements by the CTC and accounted for in the calculation of the AI, but they did not affect the LC estimates used to evaluate whether limits under Pacific Salmon Treaty management were exceeded. Under TM management, decreases in reliably estimated incidental mortalities can ultimately result in increased allowable landed catch. This situation creates an incentive to under-report releases and under-scores why fisher-reported data will require validation.

VI.7 PRE- AND POST-SEASON ESTIMATES OF IM

The CTC recommends that empirically-derived relationships of IM:LC ratios from the recent LC management period for estimating IM from LC be used for preseason projections and for post season assessment unless estimates from validated monitoring programs are available post-season. The CTC has developed some preliminary recommendations for predicting IM from LC for each gear sector in each AABM fishery. However, the CTC has not yet developed data standards for assessing whether IM can be reliably predicted, and has not yet assessed whether the predictive relationships meet those standards. Reliability and predictability of estimates of sublegal-sized encounters, as well estimates of incidental mortalities need further review by the CTC. This is due to the greater uncertainty in IM estimates relative to LC and that the IM estimates will become an explicit component of assessment of compliance under the TM regime.

The CTC recommends that these empirically-derived relationships of IM:LC ratios be periodically evaluated through direct observation programs conducted in accordance with standards established by the CTC. In addition, if the management of an AABM fishery is significantly modified (e.g., changes to size limits, implementation of mark selective fisheries, or time and area regulation), the CTC recommends that: (a) the proposing agency be required to submit methods to be employed to estimate IM for preseason planning for review by the CTC; and (b) agencies be required to conduct direct observation programs in accordance with the standards established by the CTC to estimate IM:LC ratios resulting from the management changes for post season assessment.

For pre- and post-season estimation of TM in LCEs, the CTC will also require estimates of conversion scalars derived from average AEQs from the PSC Chinook Model for computing TCEs. The CTC found that average AEQ values from post-season calibrations are adequate to use for calculating LCE scalars and estimating TM for post-season assessments. Average AEQs from the preseason Model calibration are also adequate for preseason estimates for the three SEAK sectors and WCVI troll, but not for NBC troll and WCVI sport. The CTC may need to develop and apply methods to reduce the error in preseason estimates of average AEQs in NBC troll and WCVI sport fisheries.

VI.8 PSC CHINOOK MODEL IMPROVEMENT

The CTC considered how the PSC Chinook Model could be modified to improve TM management, and identified Model improvement issues that apply not only to TM management, but more generally to AABM and ISBM fisheries under the current LC regime. The AIs generated by the Model are the basis of annual catch limits in Table 1, whether these limits are defined as LC or TM. The Model has always incorporated estimates of TM in the calculation of cohort sizes and fishery-specific AIs. However, the Model has substantial bias in estimating IM, and currently, does not account for the large temporal decreases in IM under recent management conditions. This could affect the average AEQs for SIMs and LC, and thus the LCE scalars used to construct the TM Table 1. More importantly, inaccurate representation of IM in the model could affect the AIs. Thus, changes in the Model to better represent IM could substantially change the time series of AABM AIs in relation to LC that are the basis for Table 1 for LC or TM management. For this reason, the Model improvement work is critical for AABM fisheries management and the construction of Table 1 regardless of whether catch limits are set in terms of LC or TM.

VI.9 DIRECTIVES FOR THE CTC AND TM MANAGEMENT

This report addresses the directives of the 2008 Agreement for transitioning to a TM regime in the AABM fisheries, and provides a technical basis for implementing a TM regime in 2011. The CTC emphasizes that analytical approaches and methods for revising Table 1 from LC to TM, and for implementing and assessing TM management in AABM fisheries, will evolve over time. However, while refinement of LCE scalars used in constructing Table 1 may provide a better "exchange currency" between gear sectors, the change in IM:LC ratios between the 1985-1995 base period and the current period will still result in substantial increases in TM and LC under TM limits relative to the current LC regime. The need and priority for the CTC to improve analytical approaches for TM management are dependent on the direction from the Commission regarding transition to a TM regime.

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APPENDICES

Appendix A. Regression methods and statistics used to estimate SEAK summer troll encounters when direct observational data is not available.

Linear regression models were used to estimate troll encounters from troll effort data in the absence of direct observational encounter estimates. The general equation of the regression models was:

$$C_y = \beta F_y$$

where C_y = number of Chinook salmon encountered in year y and F_y = boat-days of troll effort from year y. All regressions were forced through zero because we would not expect any Chinook encounters if there is no troll effort. Seven different models were run using data relevant to each size group (legal or sublegal), period type (CNR or CR), and the set of direct observational years. One model was run to estimate the regression coefficient for sublegals during the CR period (Table A1). Three models each were run to estimate the best regression coefficient for legals and sublegals during the CNR period (Table A1). Model 1 was chosen to estimate shaker encounters for the 1989-1995 time period, 2007, and 2008 because no other direct observational data was available. Model 2 was chosen as the best model for estimating legal CNR encounters for the 1989-1995 time period, 2007, and 2008 because the legal encounter rates during the 1985-1988 time period were similar to those observed during the 1998-2006 time period. Model 6 was chosen as the best model for estimating sublegal CNR encounters for the 1989-1995 time period and Model 7 was chosen as the best model for estimating sublegal CNR encounters for 2007 and 2008 because the sublegal encounter rates differed substantially between the 1985-1988 time period and the 1998-2006 time period. The difference in sublegal encounter rates is presumed to be a result of the troll fleet fishing different geographical areas during the two time periods.

Table A1. Regression models used to calculate Chinook salmon encounters in the SEAK summer troll fishery when direct observational data was not available.

Model #	Size Group	Period Type	Years in Model	Model Equation	n	R^2
1	Sublegal	CR	1998-2006	$C_y = 3.774F_y$	9	0.88
2	Legal	CNR	1985-1988,1998-2006	$C_y = 3.203F_y$	13	0.92
3	Legal	CNR	1985-1988,1998-2001	$C_y = 3.155F_y$	8	0.91
4	Legal	CNR	1998-2006	$C_y = 3.288F_y$	9	0.97
5	Sublegal	CNR	1985-1988,1998-2006	$C_y = 3.751F_y$	13	0.86
6	Sublegal	CNR	1985-1988,1998-2001	$C_y = 3.973F_y$	8	0.89
7	Sublegal	CNR	1998-2006	$C_y = 2.121F_y$	9	0.82

Appendix B. Winter and spring shaker encounter estimates for the SEAK troll fishery.

Year	Summer Landed Catch	Summer Shakers	Ratio of Shakers To Landed Catch In Summer	Winter Catch	Winter Shakers	Spring Catch	Spring Shakers
1985	192,986	117,272	0.61	22,825	13,870	0	0
1986	214,001	134,520	0.63	22,926	14,411	776	488
1987	209,546	82,341	0.39	28,528	11,210	4,488	1,764
1988	162,310	42,861	0.26	60,449	15,963	8,605	2,272
1989	167,614	39,650	0.24	34,297	8,113	33,805	7,997
1990	212,787	67,881	0.32	33,130	10,569	42,022	13,405
1991	154,973	26,031	0.17	42,639	7,162	66,494	11,169
1992	72,972	14,635	0.20	71,831	14,407	38,956	7,813
1993	145,465	45,641	0.31	62,722	19,680	18,679	5,861
1994	118,594	28,262	0.24	56,368	13,433	11,369	2,709
1995	97,166	34,012	0.35	17,868	6,254	23,083	8,080
1996	84,672	20,553	0.24	9,401	2,282	47,379	11,501
1997	182,730	34,570	0.19	20,957	3,965	42,722	8,082
1998	138,740	27,115	0.20	32,818	6,414	20,508	4,008
1999	94,528	12,230	0.13	30,977	4,008	20,714	2,680
2000	93,772	32,631	0.35	36,055	12,546	28,890	10,053
2001	95,363	42,259	0.44	22,586	10,009	35,331	15,657
2002	252,269	63,832	0.25	29,389	7,436	43,650	11,045
2003	240,577	46,311	0.19	50,854	9,789	39,261	7,558
2004	244,978	25,303	0.10	52,886	5,462	56,794	5,866
2005	227,280	25,348	0.11	50,470	5,629	60,696	6,769
2006	195,457	28,066	0.14	48,922	7,025	37,936	5,447
2007	171,488	39,841	0.23	46,872	10,889	49,789	11,567
2008	88,970	21,437	0.24	21,824	5,258	41,132	9,911

Appendix C. Chinook salmon encounter estimates from observational studies in the SEAK net fishery.

								Encounter Estimates					
		Period	Dates			Landed Catch		Size Category			Total		
Year	Period	Type	Begin	End	Landings	Legal	Sublegal	< 21"	21" - 28"	> 28"	Sublegal	Legal	Method/Comment
1985	1	CR	07/07/85	08/10/85	5,754	14,964	4,988						Leg LC=19,952 Tot LC*0.75
1985	2	CNR	08/11/85	09/02/85	5,614	44	15	38,995	5,684	12,426	44,679	12,426	Leg LC=58 Tot LC*0.75, Chinook/Set Method, Leg=Med+Lrg Wgt
1986	1	CNR	07/06/86	07/26/86	1,859	64	171						
1986	2	CR	07/27/86	08/09/86	3,103	11,277	194						
1986	3	CNR	08/10/86	09/01/86	5,288	43	226	21,856	4,994	13,773	26,850	13,773	Chinook/Set Method, (per 1 & 3 combined)
1987	1	CNR	06/28/87	08/01/87	2,223	206	770	6,885	2,133	1,920	9,018	1,920	Sub=Dockside Interviews, Leg=Fish Tickets
1987	2	CR	08/02/87	10/31/87	2,359	3,973	716	3,406	1,499	3,970	4,905	3,970	Sub=Dockside Interviews, Leg=Fish Tickets
1988	1	CNR	07/03/88	08/01/88	2,685	68	384	4,781	4,786	11,957	9,567	11,957	Dockside Interviews
1988	2	CR	08/07/88	08/18/88	2,004	7,507	158	2,509	677	3,619	3,185	3,619	Dockside Interviews
1988	3	CNR	08/21/88	08/21/88	525	50	122	567	84	849	651	849	Dockside Interviews
1988	4	CR	08/24/88	08/25/88	713	2,931	9	1,397	236	2,227	1,633	2,227	Dockside Interviews
1988	5	CNR	08/28/88	09/15/88	1,379	20	170	603	14	139	616	139	Dockside Interviews
2004	1	CR	06/20/04	08/13/04	3,526	33,317	523	2,209	3,283	33,136	5,492	33,136	Logbook Catch/Landing
2004	2	CNR	08/14/04	10/31/04	1,557	24	66	839	569	12,689	1,408	12,689	Logbook Catch/Landing
2005	1	CR	06/19/05	10/31/05	5,579	15,399	663	5,429	2,337	14,346	7,766	14,346	Logbook Catch/Landing

Appendix D. Landed catch (LC) and total mortality (TM) estimates under LC and TM regimes for AABM fisheries for the range of AIs listed in Table 1 from Annex IV, Chapter 3 of the 2008 Agreement. Under the LC regime, LC_{lc} is from Table 1 and current expected TM_{lc} was estimated using current (1999-2008) IM rates as per Section II of the TM report. Under the TM regime, expected TM_{tm} was determined from Table 1 LC using base period (1985-1995) IM rates; expected LC_{tm} under the TM regime was then determined by applying 1999-2008 IM rates and current gear-specific allocations of LC. How these four quantities were derived and their role under the TM regime to be implemented in 2011 are first illustrated below. Three separate tables, one for each AABM fishery, then follow showing each quantity at the Table 1 AIs.

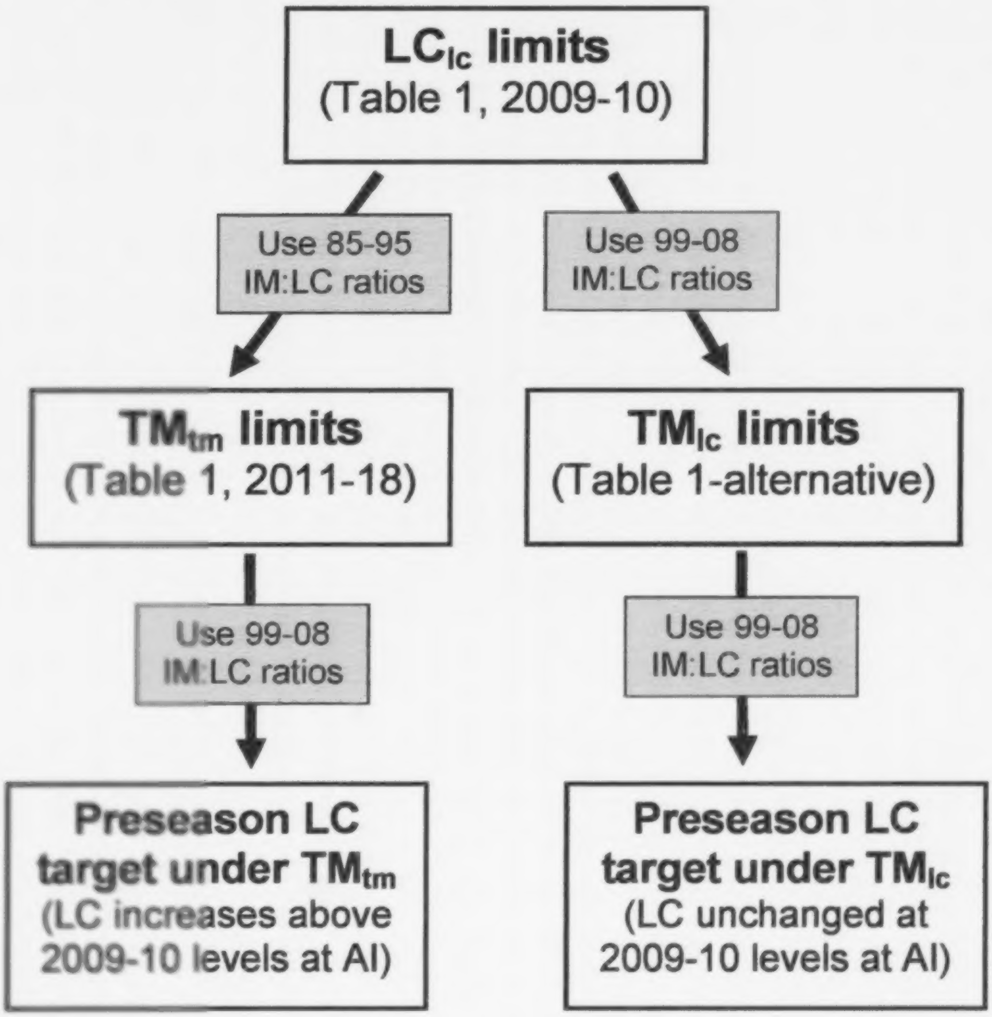


Table D.1. SEAK AABM Fishery.

AI	LC Regime		TM Regime	
	LC_{lc}	TM_{lc}	LC_{tm}	TM_{tm}
0.25	44,600	50,552	60,348	68,453
0.30	50,200	54,489	69,154	75,490
0.35	55,700	60,583	75,392	82,402
0.40	61,200	66,677	81,630	89,314
0.45	66,700	72,771	87,868	96,225
0.50	71,700	78,311	93,539	102,509
0.50	72,300	78,976	94,219	103,263
0.55	77,800	85,070	100,457	110,175
0.60	83,300	91,164	106,695	117,086
0.65	88,800	97,258	112,933	123,998
0.70	94,400	103,463	119,285	131,036
0.75	99,900	109,557	125,523	137,948
0.80	105,400	115,651	131,761	144,859
0.85	110,900	121,745	137,999	151,771
0.90	116,500	127,950	144,350	158,809
0.95	122,000	134,044	150,588	165,720
1.00	127,500	140,138	156,826	172,632
1.01	128,700	141,468	158,187	174,140
1.05	139,600	153,545	170,550	187,838
1.10	151,700	166,952	184,273	203,044
1.15	163,800	180,360	197,997	218,250
1.20	176,000	193,877	211,834	233,582
1.21	199,800	220,248	238,827	263,491
1.25	206,700	227,893	246,653	272,162
1.30	214,200	236,204	255,159	281,587
1.35	221,800	244,625	263,779	291,138
1.40	229,400	253,045	272,399	300,689
1.45	237,000	261,466	281,019	310,240
1.50	244,600	269,887	289,638	319,791
1.51	264,400	291,826	312,095	344,673
1.55	271,800	300,025	320,488	353,973
1.60	280,000	309,111	329,788	364,278
1.65	288,200	318,197	339,089	374,583
1.70	296,400	327,283	348,389	384,887
1.75	304,600	336,368	357,689	395,192
1.80	312,900	345,565	367,103	405,623
1.85	321,100	354,651	376,403	415,928
1.90	329,300	363,736	385,703	426,233
1.95	337,500	372,822	395,004	436,537
2.00	345,700	381,908	404,304	446,842
2.05	353,900	390,994	413,604	457,147
2.10	362,200	400,190	423,018	467,578
2.15	370,400	409,276	432,318	477,883
2.20	378,600	418,362	441,619	488,187
2.25	386,800	427,448	450,919	498,492

Table D.2. NBC AABM Fishery.

	LC Regime		TM Regime	
AI	LC_{lc}	TM_{lc}	LC_{tm}	TM_{tm}
0.25	32,500	34,609	34,170	38,929
0.30	39,000	41,531	41,093	46,714
0.35	45,500	48,453	48,534	54,500
0.40	52,000	55,375	55,975	62,286
0.45	58,500	62,297	63,416	70,072
0.50	64,400	68,580	70,170	77,139
0.50	65,000	69,219	70,857	77,857
0.55	71,500	76,141	78,298	85,643
0.60	78,000	83,063	85,739	93,429
0.65	84,500	89,984	93,181	101,215
0.70	91,000	96,906	100,622	109,000
0.75	97,500	103,828	108,063	116,786
0.80	104,000	110,750	115,504	124,572
0.85	110,500	117,672	122,945	132,358
0.90	117,000	124,594	130,386	140,143
0.95	123,500	131,516	137,827	147,929
1.00	130,000	138,438	145,269	155,715
1.01	130,700	139,183	146,070	156,553
1.05	136,500	145,359	152,710	163,501
1.10	143,000	152,281	160,151	171,286
1.15	149,500	159,203	167,592	179,072
1.20	156,000	166,125	175,033	186,858
1.21	156,700	166,871	175,834	187,696
1.25	163,300	173,899	183,390	195,602
1.30	170,700	181,779	191,862	204,466
1.35	178,000	189,553	200,219	213,210
1.40	185,300	197,327	208,575	221,954
1.45	192,700	205,207	217,047	230,817
1.50	200,000	212,981	225,404	239,561
1.51	219,600	233,853	247,842	263,038
1.55	226,100	240,775	255,283	270,824
1.60	233,400	248,549	263,640	279,568
1.65	240,700	256,323	271,997	288,312
1.70	248,000	264,096	280,354	297,056
1.75	255,300	271,870	288,711	305,800
1.80	262,600	279,644	297,068	314,544
1.85	269,900	287,418	305,425	323,288
1.90	277,200	295,192	313,782	332,032
1.95	284,500	302,965	322,139	340,776
2.00	291,800	310,739	330,496	349,520
2.05	299,100	318,513	338,853	358,264
2.10	306,400	326,287	347,210	367,008
2.15	313,700	334,061	355,567	375,752
2.20	321,000	341,834	363,924	384,496
2.25	328,300	349,608	372,281	393,240

Table D.3. WCVI AABM Fishery.

	LC Regime		TM Regime	
AI	LC_{lc}	TM_{lc}	LC_{tm}	TM_{tm}
0.25	32,100	34,627	34,761	40,950
0.30	38,500	41,531	41,691	49,115
0.35	44,900	48,435	48,622	57,279
0.40	51,300	55,339	56,207	65,444
0.45	57,800	62,350	64,075	73,736
0.50	63,500	68,499	70,974	81,007
0.50	74,900	80,797	84,774	95,550
0.55	82,400	88,887	93,852	105,118
0.60	89,800	96,870	102,810	114,558
0.65	97,300	104,960	111,888	124,126
0.70	104,800	113,050	120,966	133,694
0.75	112,300	121,141	130,045	143,261
0.80	119,800	129,231	139,123	152,829
0.85	127,300	137,322	148,202	162,397
0.90	134,800	145,412	157,280	171,965
0.95	142,300	153,503	166,359	181,532
1.00	149,700	161,485	175,316	190,973
1.01	172,000	185,541	202,310	219,421
1.05	179,700	193,847	211,630	229,244
1.10	188,200	203,016	221,919	240,087
1.15	196,800	212,293	232,329	251,058
1.20	205,400	221,570	242,739	262,029
1.21	206,200	222,433	243,708	263,050
1.25	213,900	230,739	253,028	272,873
1.30	222,500	240,016	263,438	283,844
1.35	231,000	249,186	273,727	294,687
1.40	239,600	258,463	284,137	305,658
1.45	248,100	267,632	294,426	316,502
1.50	256,700	276,909	304,836	327,473
1.51	257,600	277,880	305,926	328,621
1.55	265,300	286,186	315,246	338,444
1.60	273,800	295,355	325,535	349,287
1.65	282,400	304,632	335,945	360,258
1.70	290,900	313,801	346,234	371,102
1.75	299,500	323,078	356,644	382,073
1.80	308,000	332,247	366,933	392,916
1.85	316,600	341,524	377,343	403,887
1.90	325,100	350,694	387,632	414,731
1.95	333,700	359,971	398,042	425,702
2.00	342,300	369,248	408,452	436,673
2.05	350,800	378,417	418,741	447,517
2.10	359,400	387,694	429,151	458,488
2.15	367,900	396,863	439,440	469,331
2.20	376,500	406,140	449,850	480,302
2.25	385,000	415,309	460,139	491,146

Appendix E. Memorandum to the CTC describing the Probability of Recruitment (PR) method for calculating landed-catch equivalents.

MEMORANDUM

TO: CTC Total Mortality WorkGroup

FR: Gary S. Morishima

Re: Using Probability of Recruitment to Compute Landed Catch Equivalents –

Date: April 14, 2009

Preface:

In Paragraph 7 of the 2008 Agreement, the U.S. and Canada agreed to implement total mortality fishing regime. This repeatedly employs the term "Landed Catch Equivalent" (LCE), but leaves it up to the CTC to develop a *"means to ensure that changes in the conduct of an AABM fishery do not increase total landed catch equivalent fishing mortality above the levels appropriate to a given abundance index"* (footnote 3). A Total Mortality Work Group (TMWG) of the CTC has been created to undertake this assignment.

The charge given to the TMWG, although somewhat circular, appears to involve two principal tasks:

(a) develop a new Table 1, based on estimates incidental fishing mortality associated with landed catch for the gears included under AABM regimes for the period 1985-1995, para 7(f)(i);

(b) develop a method to convert landed catch and incidental mortalities between and within gears into a common currency, para 7(f)(ii)&(v).

<u>Task (a):</u> To improve transparency and facilitate conversions between landed catch and incidental mortalities within and between gears, it would be helpful to employ a different format for Table 1, one which separates mortalities into sector-specific estimates of Landed Catch (LC), Legal Sized Incidental Mortalities (LIM), and Sublegal Incidental Mortalities (SIM).

Task (b): The purpose of this memo is to describe how the concept of *Probability of Recruitment* (PR) could be employed to establish a common currency.

Which common currency?

Different types of common currencies for implementation of total mortality could be developed. One type, adult equivalence or AEQs, has been employed by the CTC to express catch and incidental mortalities in terms of potential contributions to terminal run sizes <u>in the absence of fishing in the current and future years</u>.

Because they assume no fishing mortality, AEQs have obvious limitations and implications if used to convert different types of fishing mortalities into LCEs for implementation of AABM total mortality regimes. The allowable catch levels in Table 1 are intended to constrain the harvest rates for the main mixed stock fishery (troll sector) at given levels of abundance, and, by implication, the harvest rate of the entire AABM complex under specific assumptions regarding distribution of catch among the gears included under AABM regimes. When the distribution of catch or incidental fishing mortalities deviates from these assumptions, the harvest rate imparted by the AABM fishery complex can be affected as impacts are redistributed among the stocks and ages in the catch and incidental mortalities.

PR scalars provide a means to convert different types of fishing mortalities into a common currency within and between the gears included in AABM regimes by considering relationships between different minimum size limits restrictions.

Basics:

PRs are multiplicative scalar values for converting quantities of different types of mortalities into a common currency. PR *"to:from orTOfish: FRfish"* conversions depend upon (1) the type of mortality being converted; (2) the type of common currency desired; (3) stock-age specific growth functions; and (4) relationships between the minimum size limits for the fisheries involved in the conversion. For convenience, the notation $PR\langle b|a\rangle$ will be employed throughout this memo to represent the conversion from mortality type ***a*** to mortality type ***b***.

Like AEQs, PR's are stock-age-specific since they depend on maturation rates and the proportion of a cohort that is vulnerable (PV), i.e., above a minimum size limit for retention. Figure 1 illustrates how a minimum size limit (green vertical line) is presumed to affect the PV and PNV. The area to the left of the vertical green line is the PNV while the area to the right is the PV (Fig 1).

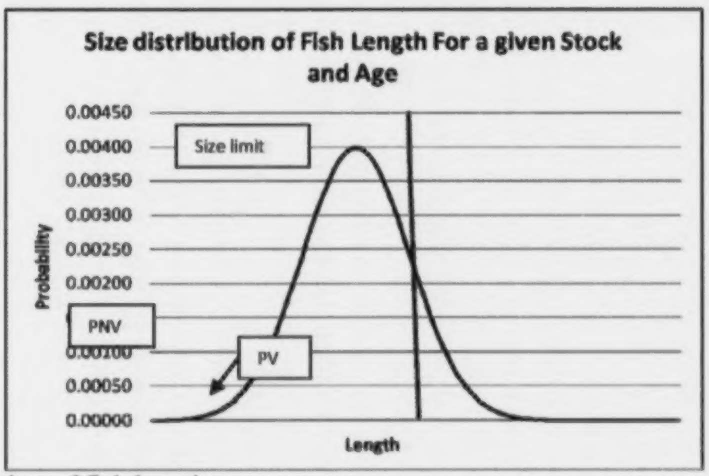


Fig 1. Size distribution of fish length

Integration methods must be employed to compute the areas under different portions of the normal distribution. Alternatively, the PNV and hence the PV (1-PNV) can be more readily computed using cumulative distribution function (CDF). In 2005, Morishima & Chen estimated parameters for stock-specific von Bertalanffy growth functions for various populations of Chinook, based on

run timing and basin. The means and standard deviations from these growth functions can be used to generate stock-age specific CDFs (fig 2), using a variety of algorithms, such as that embodied in the NORMDIST function build into Excel with the last parameter=TRUE.

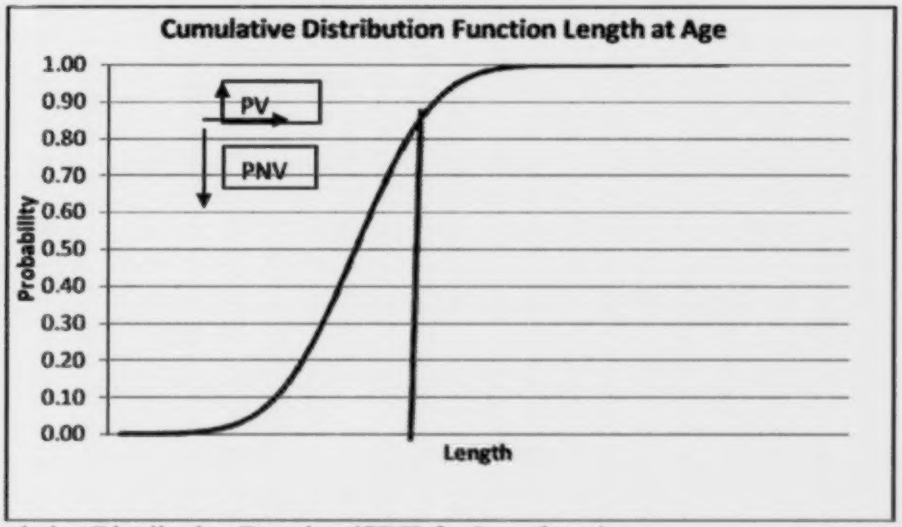


Fig 2. Cumulative Distribution Function (CDF) for Length at Age

SECTION A: Conversion Within Gears (i.e., constant PVs)

This type of conversion would be suitable for construction of a total mortality version of Table 1 with explicit LCEs for each sector included in the AABM complex (task a).

Obviously, the probability that a legal sized fish (retained catch or LIM) will stay legal =1 and the probability that a fish that is already legal sized will become sublegal = 0.

$$PR_{s,a,f}\left\langle L_{s,a,f} \middle| L_{s,a,f} \right\rangle = 1.0 \tag{1}$$

$$PR_{s,a,f}\left\langle SL_{s,a,f} \middle| L_{s,a,f} \right\rangle = 0.0 \tag{2}$$

The only conversion possible is for a fish that is sublegal to become legal sized. A schematic of the computations involved for age 2 fish is depicted in fig 3. The shaded areas are sublegal sized fish. The arrows cascading from figure to figure illustrate that the sublegal fish from different ages may become legal sized fish in each successive age. The curves shift to the right to indicate the expected size distribution of fish as they age. The curves become progressively smaller as populations are reduced from processes of maturation and natural mortality.

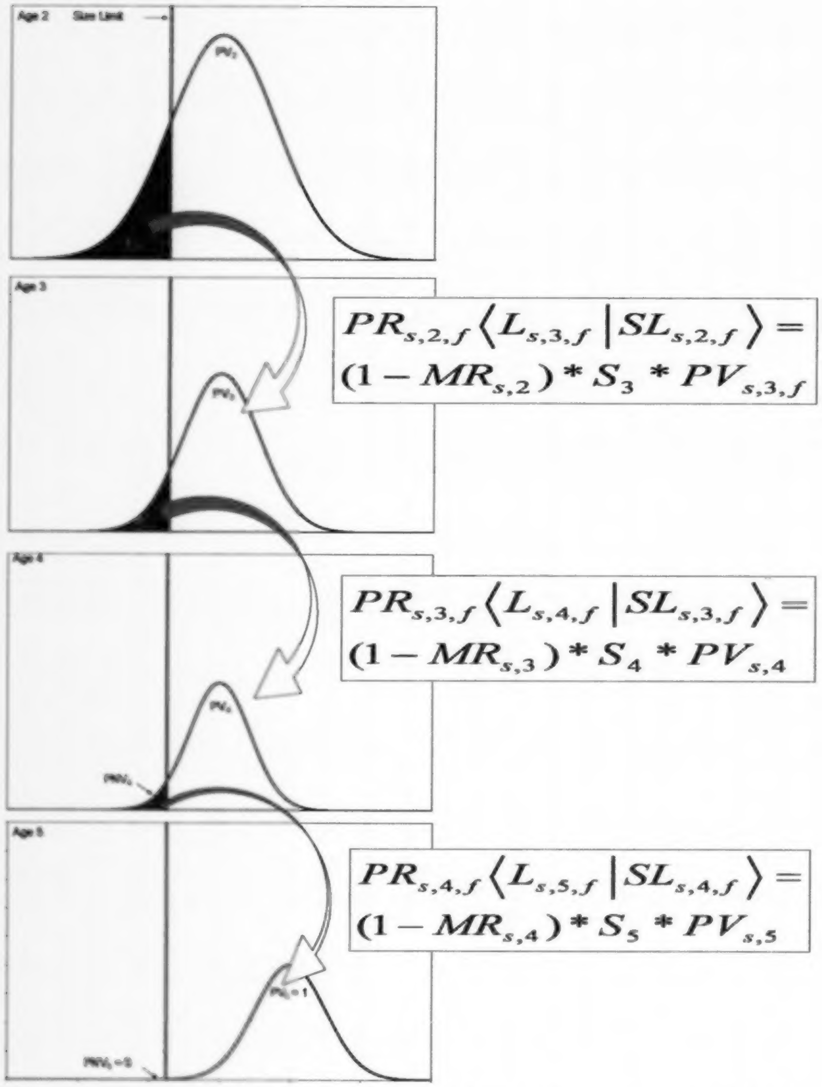


Fig 3. Graphic illustration of how probability of recruitment of sublegal sized fish to legal sized fish is computed.

<u>AGE 2</u>: The probability that an age 2 SIM will become legal sized at age 3 is:

$$PR_{s,2,f}\left\langle L_{s,3,f} \middle| SL_{s,2,f} \right\rangle = (1 - MR_{s,2}) * S_3 * PV_{s,3,f} \tag{3}$$

The probability that an age 2 SIM will become legal sized at age 4 is:

$$\begin{aligned} PR_{s,2,f}\left\langle L_{s,4,f} \middle| SL_{s,2,f} \right\rangle &= (1 - MR_{s,2}) * S_3 * PNV_{s,3,f} * (1 - MR_{s,3}) * S_4 * PV_{s,4,f} \\ &= PR_{s,2,f}\left\langle L_{s,3,f} \middle| SL_{s,2,f} \right\rangle * \frac{PNV_{s,3,f}}{PV_{s,3,f}} * (1 - MR_{s,3}) * S_4 * PV_{s,4,f} \end{aligned} \tag{4}$$

The probability that an age 2 SIM will become legal sized at age 5 is:

$$PR_{s,2,f}\left\langle L_{s,5,f}\left|SL_{s,2,f}\right.\right\rangle = PR_{s,2,f}\left\langle L_{s,4,f}\left|SL_{s,2,f}\right.\right\rangle * \frac{PNV_{s,4,f}}{PV_{s,4,f}} * (1-MR_{s,4}) * S_5 * PV_{s,5,f} \quad (5)$$

So the total probability of recruitment for an age 2 SIM is:

$$PR_{s,2,f}\left\langle L_{s,\cdot,f}\left|SL_{s,2,f}\right.\right\rangle = (3)+(4)+(5) \quad (6)$$

<u>AGE 3</u>: Similarly, the probability of an age 3 SIM becoming legal sized at age 4 is:

$$PR_{s,3,f}\left\langle L_{s,4,f}\left|SL_{s,3,f}\right.\right\rangle = (1-MR_{s,3}) * S_4 * PV_{s,4} \quad (7)$$

The probability that an age 3 SIM will become legal sized at age 5 is:

$$PR_{s,3,f}\left\langle L_{s,5,f}\left|SL_{s,3,f}\right.\right\rangle = PR_{s,3,f}\left\langle L_{s,4,f}\left|SL_{s,3,f}\right.\right\rangle * \frac{PNV_{s,4,f}}{PV_{s,4,f}} * (1-MR_{s,4}) * S_5 * PV_{s,5,f} \quad (8)$$

So the total probability of recruitment for an age 3 SIM is:

$$PR_{s,3,f}\left\langle L_{s,\cdot,f}\left|SL_{s,3,f}\right.\right\rangle = (6)+(7) \quad (9)$$

<u>AGE 4</u>: Continuing, the probability of an age 4 SIM becoming legal sized at age 5 is:

$$PR_{s,4,f}\left\langle L_{s,5,f}\left|SL_{s,4,f}\right.\right\rangle = (1-MR_{s,4}) * S_5 * PV_{s,5} \quad (10)$$

Finally, the probability of an age 5 SIM becoming legal at age 5 =0.

$$PR_{s,5,f}\left\langle L_{s,5,f}\left|SL_{s,5,f}\right.\right\rangle = 0 \quad (11)$$

SECTION B: Conversion Between Fisheries With Different Size Limits (Within or Between Gears, i.e., different PVs)

When different types of mortalities are to be converted between fisheries (or when conversions are needed because of a regulatory change like modification of a minimum size limit that affects the PV), a set of PR scalars is required. Four types of conversions are possible. Fish that are legal or sublegal in FRfish may be legal or sublegal in TOfish and vice-versa (fig 4).

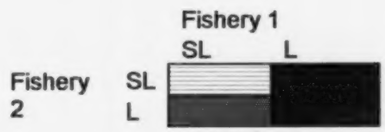


Fig 4. Different components involved when computing LCEs

To convert between types of mortalities, PR scalars incorporate the relationship between the size limits and associated PVs in the fisheries (fig 5).

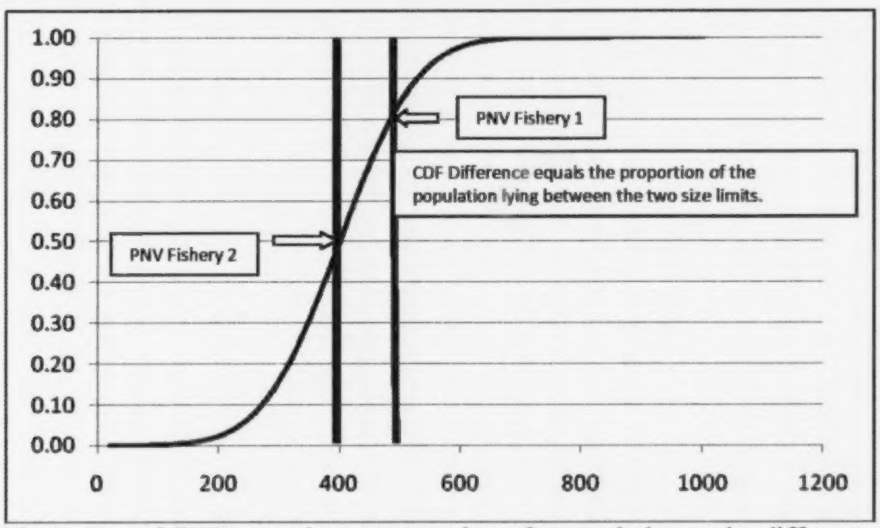


Fig 5. Use of CDFs to estimate proportion of a population under different size limits.

Case B-1: Legal:Legal Conversions

Conversion of legal sized fish from fishery 1 to a legal sized fish in fishery 2 depends on the relationship between the PVs in the fisheries (fig 6):

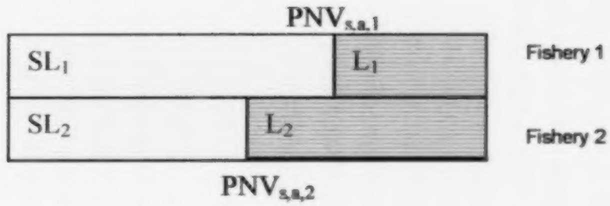
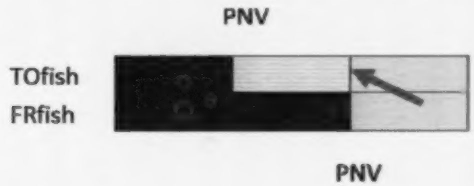


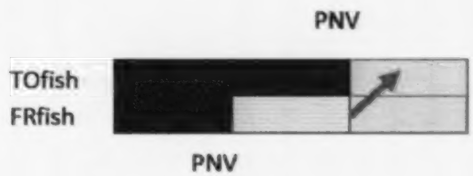
Fig 6. Legal components of exploited population when the size limit in fishery 1 is larger than the size limit in fishery 2.

<u>CASE B-1-1: Legal:Legal conversions when Size limit in FRfish > size limit in TOfish</u>. In this case, fish that are legal in FRfish are also legal in TOfish



$$PR_{s,a,F}\left\langle L_{s,a,T} \middle| L_{s,a,F} \right\rangle = 1.0 \tag{12}$$

<u>CASE B-1-2: Legal:Legal conversions when Size limit in FRfish < size limit in TOfish</u>



In this circumstance, conversion of legal sized mortalities TOfish:FRfish involves two components: (1) fish that are legal sized fish in both fisheries can be converted 1:1 (green); and (2) fish that are legal sized in FRfish, but sublegal in TOfish (orange).

Component (1) (green):

$$PR_{s,a,F}\left\langle L_{s,a,T} \middle| L_{s,a,F} \right\rangle = \frac{(1-PNV_{s,a,T})}{(1-PNV_{s,a,F})} \tag{13}$$

Component (2) (orange): The probability of recruitment for the remainder of the legal catch in TOfish involves consideration of maturation rates, survival rates, and PVs. The proportion of age a fish in the landed catch in FRfish that is sublegal in TOfish is:

$$X_a = \frac{\lfloor PNV_{s,a,T} - PNV_{s,a,F} \rfloor}{PV_{s,a,F}} \qquad \text{(X)}$$

AGE 2: The probability that an Age 2 LC in FRfish which is below the size limit for TOfish will reach legal size in TOfish at age 3 is:

$$PR_{s,2,F}\langle L_{s,3,T} \mid L_{s,2,F} \rangle = (1 - MR_{s,2}) * S_3 * PV_{s,3,T} \qquad (14)$$

The probability that an Age 2 LC in FRfish which is below the size limit for TOfish will reach legal size in TOfish at age 4 is:

$$PR_{s,2,F}\langle L_{s,4,T} \mid L_{s,2,F} \rangle = (1 - MR_{s,2}) * S_3 * \frac{PNV_{s,3,T}}{PV_{s,3,T}} * (1 - MR_{s,3}) * S_4 * PV_{s,4,T} \qquad (15)$$

The probability that an Age 2 LC in FRfish which is below the size limit for TOfish will reach legal size in TOfish at age 5 is:

$$PR_{s,2,F}\langle L_{s,5,T} \mid L_{s,2,F} \rangle = PR_{s,2,F}\langle L_{s,4,T} \mid L_{s,2,F} \rangle * \frac{PNV_{s,4,F}}{PV_{s,4,F}} * (1 - MR_{s,4}) * S_5 * PV_{s,5,T} \qquad (16)$$

So the Total probability of recruitment for an age 2 LC in FRfish for a LC in TOfish is:

$$PR_{s,2,F}\langle L_{s,.,T} \mid L_{s,2,F} \rangle = (13) + X_2 * [(14) + (15) + (16)] \qquad (17)$$

AGE 3: The probability that an Age 3 LC in FRfish which is below the size limit for TOfish will reach legal size in TOfish at age 4 is:

$$PR_{s,3,F}\langle L_{s,4,T} \mid L_{s,3,F} \rangle = (1 - MR_{s,3}) * S_4 * PV_{s,4,T} \qquad (18)$$

The probability that an Age 3 LC in FRfish which is below the size limit for TOfish will reach legal size in TOfish at age 5 is:

$$PR_{s,3,F}\langle L_{s,5,T} \mid L_{s,3,F} \rangle = PR_{s,3,F}\langle L_{s,4,T} \mid L_{s,3,F} \rangle * \frac{PNV_{s,4,T}}{PV_{s,4,T}} * (1 - MR_{s,4}) * S_5 * PV_{s,5,T} \qquad (19)$$

The total probability that an Age 3 fish would reach legal size in TOfish is:

$$PR_{s,2,F}\langle L_{s,.,T} \mid L_{s,3,F} \rangle = (13) + X_3 * [(18) + (19)] \qquad (20)$$

AGE 4: The probability that an Age 4 LC in FRfish which is below the size limit for TOfish will reach legal size in TOfish at age 5 is:

$$PR_{s,4,F}\langle L_{s,5,T} \mid L_{s,4,F} \rangle = (1 - MR_{s,4}) * S_5 * PV_{s,5,T} \qquad (21)$$

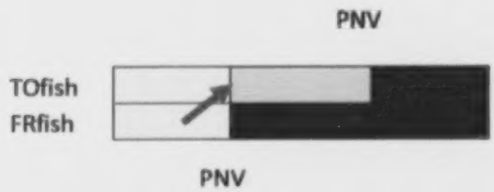
So the Total probability of recruitment for an age 4 LC in FRfish for a LC in TOfish is:

$$PR_{s,4,F}\left\langle L_{s,\_T} \middle| L_{s,4,F} \right\rangle = (13) + X_4 * (21) \tag{22}$$

<u>AGE 5</u>: The proportion of the age 5 landed catch in FRfish that is legal in TOfish:

$$PR_{s,5,F}\left\langle L_{s,5,T} \middle| L_{s,4,F} \right\rangle = (13) \tag{23}$$

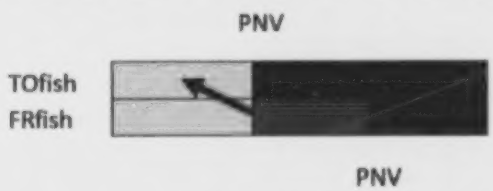
<u>Case B-2-1: SubLegal:SubLegal conversions when the size limit for TOfish > size limit in FRfish</u>



Obviously, a fish that is sublegal in FRfish is also sublegal in TOfish, so the probability of recruitment =1 (yellow).

$$PR_{s,a,F}\left\langle SL_{s,a,T} \middle| SL_{s,a,F} \right\rangle = 1.0 \tag{24}$$

<u>Case B-2-2: SubLegal:SubLegal conversions when the size limit for TOfish < size limit in FRfish</u>



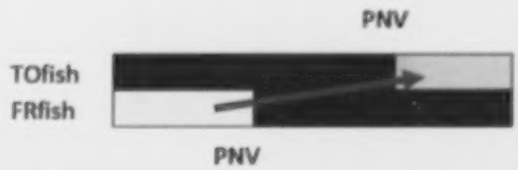
A fish that is sublegal in FRfish may either be legal or sublegal in TOfish. In this case, only a portion (yellow) of the sublegal FRfish mortalities can be converted to sublegal TOfish mortalities; the remaining portion (orange) cannot be recruited to sublegal fish in TOfish. The probability of recruitment of a sublegal sized fish in FRfish to a sublegal sized fish in TOfish is:

$$PR_{s,a,F}\left\langle SL_{s,a,T} \middle| SL_{s,a,F} \right\rangle = \frac{PV_{s,a,F} - PV_{s,a,T}}{PV_{s,a,F}} \tag{25}$$

Case B-3: Legal:Sublegal Conversions

This is the most complex situation.

Case B-3-1. Legal:Sublegal conversions when Size Limit in FRfish < Size Limit in TOFish (FRFish = Fishery 1; TOFish = Fishery 2 in fig 5). Since a fish that is sublegal in FRfish is also sublegal in TOfish, the probability of recruitment involves a set of formulas analogous to those presented in Section A (yellow to green).



AGE 2: The probability that an age 2 sublegal sized fish in FRFish will become legal size at age 3 in TOfish:

$$PR_{s,2,F}\langle L_{s,3,T}\,|\,SL_{s,2,F}\rangle = (1 - MR_{s,2}) * S_3 * PV_{s,3,T} \tag{26}$$

The probability that an age 2 sublegal sized fish in FRFish will become legal size at age 4 in TOfish:

$$PR_{s,2,F}\langle L_{s,4,T}\,|\,SL_{s,2,F}\rangle = PR_{s,2,F}\langle L_{s,3,T}\,|\,SL_{s,2,F}\rangle * \frac{PNV_{s,3,T}}{PV_{s,3,T}} * (1 - MR_{s,3}) * S_4 * PV_{s,4,T} \tag{27}$$

The probability that an age 2 sublegal sized fish in FRFish will become legal size at age 5 in TOfish:

$$PR_{s,2,F}\langle L_{s,5,T}\,|\,SL_{s,2,F}\rangle = PR_{s,2,F}\langle L_{s,4,T}\,|\,SL_{s,2,F}\rangle * \frac{PNV_{s,4,T}}{PV_{s,4,T}} * (1 - MR_{s,4}) * S_5 * PV_{s,5,T} \tag{28}$$

The probability of recruitment for Age 2 sublegal-sized fish in FRfish to legal sized fish in TOfish is the sum of these components.

$$PR_{s,2,F}\langle L_{s,.,T}\,|\,SL_{s,2,F}\rangle = (26) + (27) + (28) \tag{29}$$

AGE 3: The probability that an age 3 sublegal sized fish in FRFish will become legal size at age 4 in TOfish:

$$PR_{s,3,F}\langle L_{s,4,T}\,|\,SL_{s,3,F}\rangle = (1 - MR_{s,3}) * S_4 * PV_{s,4,T} \tag{30}$$

The probability that an age 3 sublegal sized fish in FRFish will become legal size at age 5 in TOfish:

$$PR_{s,3,F}\langle L_{s,5,T}\,|\,SL_{s,3,F}\rangle = PR_{s,3,F}\langle L_{s,4,T}\,|\,SL_{s,3,F}\rangle * \frac{PNV_{s,4,T}}{PV_{s,4,T}} * (1 - MR_{s,4}) * S_5 * PV_{s,5,T} \tag{31}$$

The probability of recruitment for Age 3 sublegal-sized fish in FRfish to legal sized fish in TOfish is the sum of these two components.

$$PR_{s,3,F}\langle L_{s,3,T} | SL_{s,3,F} \rangle = (30) + (31) \tag{32}$$

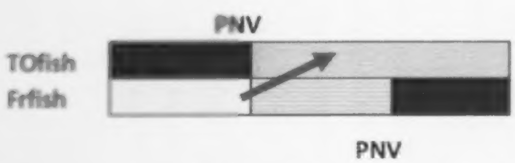
AGE 4: The probability that an age 4 sublegal sized fish in FRFish will become legal size at age 5 in TOfish:

$$PR_{s,4,F}\langle L_{s,5,T} | SL_{s,4,F} \rangle = (1 - MR_{s,4}) * S_5 * PV_{s,5,T} \tag{33}$$

AGE 5: The probability that an age 5 sublegal sized fish in FRFish will become legal size at age 5 in TOfish = 0.

$$PR_{s,5,F}\langle L_{s,5,T} | SL_{s,5,F} \rangle = 0 \tag{34}$$

Case B-3-2. Legal:Sublegal conversions when the Size Limit in TOfish < Size Limit in FRFish (FRFish = Fishery 2; TOFish = Fishery 1 in fig 5). A fish that is sublegal in FRfish may either be sublegal or legal in TOfish.



The proportion of sublegal sized fish in FRfish to legal sized fish in TOFish involves two components: (1) The proportion that is already legal (orange); and (2) The proportion that may reach legal size in TOFish in future years (yellow).

Component 1 (orange): The proportion that is already legal is:

$$PR_{s,a,F}\langle L_{s,a,T} | SL_{s,a,F} \rangle = \frac{PNV_{s,a,F} - PNV_{s,a,T}}{PNV_{s,a,F}} \tag{35}$$

The second component involves a set of computations for each age:

Component 2 (yellow): The proportion of the sublegal fish in FRfish that will become legal in TOfish in the future:

$$Y_a = \frac{PNV_{s,a,T}}{PNV_{s,a,F}} \tag{Y}$$

AGE 2. The probability that an age 2 sublegal fish in both FRfish & TOfish will become legal in TOfish at age 3 is:

$$PR_{s,2,F}\langle L_{s,3,T} | SL_{s,2,F}\rangle = (1-MR_{s,2}) * S_3 * PV_{s,3,T} \quad (36)$$

The probability that an age 2 sublegal fish in both FRfish & TOfish will become legal in fishery 2 at age 4 is:

$$PR_{s,2,F}\langle L_{s,4,T} | SL_{s,2,F}\rangle = PR_{s,2,F}\langle L_{s,3,T} | SL_{s,2,F}\rangle * \frac{PNV_{s,3,T}}{PV_{s,3,T}} * (1-MR_{s,3}) * S_4 * PV_{s,4,T} \quad (37)$$

The probability that an age 2 sublegal fish in both FRfish & TOfish will become legal in TOfish at age 5 is:

$$PR_{s,2,F}\langle L_{s,5,T} | SL_{s,2,F}\rangle = PR_{s,2,F}\langle L_{s,4,T} | SL_{s,2,F}\rangle * \frac{PNV_{s,4,T}}{PV_{s,4,T}} * (1-MR_{s,4}) * S_5 * PV_{s,5,T} \quad (38)$$

The probability that an age 2 sublegal fish in both FRfish & TOfish will become legal in TOfish at any age is:

$$PR_{s,2,F}\langle L_{s,.,T} | SL_{s,2,F}\rangle = Y_2 * [(36)+(37)+(38)] \quad (39)$$

<u>AGE 3</u>. The probability that an age 3 sublegal fish in both fisheries 1&2 will become legal in TOfish at age 4 is:

$$PR_{s,3,F}\langle L_{s,4,T} | SL_{s,3,F}\rangle = (1-MR_{s,3}) * S_4 * PV_{s,4,T} \quad (40)$$

The probability that an age 3 sublegal fish in both FRfish & TOfish will become legal in TOfish at age 5 is:

$$PR_{s,3,F}\langle L_{s,5,T} | SL_{s,3,F}\rangle = PR_{s,3,F}\langle L_{s,4,T} | SL_{s,3,F}\rangle * \frac{PNV_{s,4,T}}{PV_{s,4,T}} * (1-MR_{s,4}) * S_5 * PV_{s,5,T} \quad (41)$$

The probability that an age 3 sublegal fish in both FRfish & TOfish will become legal in TOfish at any age is:

$$PR_{s,3,F}\langle L_{s,.,T} | SL_{s,3,F}\rangle = Y_3 * [(40)+(41)] \quad (42)$$

<u>AGE 4</u>. The probability that an age 4 sublegal fish in both FRfish & TOfish and will become legal in TOfish at age 5 is:

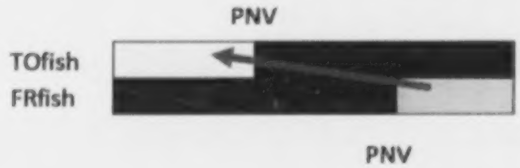
$$PR_{s,4,F}\langle L_{s,5,T} | SL_{s,4,F}\rangle = Y_4 * (1-MR_{s,4}) * S_5 * PV_{s,5,T} \quad (43)$$

<u>AGE 5</u>. The probability that an age 5 sublegal fish in both FRfish & TOfish and will become legal in TOfish at age 5:

$$PR_{s,5,F}\langle L_{s,5,T} | SL_{s,5,F}\rangle = 0 \quad (44)$$

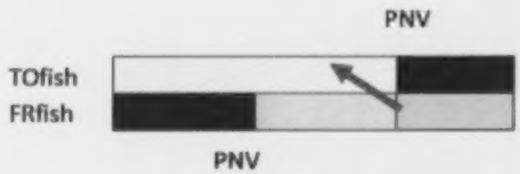
Case B-4: SubLegal:Legal Conversions

Case B-4-1: Size limit in FRfish > size limit in TOfish (green to yellow). In this case, the probability of recruitment of a sublegal-sized fish in fishery 1 to become legal in fishery 2 =0:



$$PR_{s,a,F}\left\langle SL_{s,a,T}\middle|L_{s,a,F}\right\rangle = 0 \tag{45}$$

Case B-4-2: Size limit in FRfish < size limit in TOfish (green:yellow). In this case, the portion of the LC for FRfish that would be sublegal in TOFish, lies between the two size limits (bright green); a portion of the LC in FRfish is already LC in TOfish (dark green):



$$Z_a = \frac{PNV_{s,a,T} - PNV_{s,a,F}}{PV_{s,a,F}} \tag{Z}$$

<u>AGE 2</u>: The probability that age 2 sublegal sized fish in FRfish which is larger than the minimum size limit of FRfish and smaller than the minimum size limit for TOfish (bright green) will remain below the minimum size limit in TOfish at age 3 is:

$$PR_{s,2,F}\left\langle SL_{s,3,T}\middle|L_{s,2,F}\right\rangle = (1-MR_{s,2}) * S_3 * PNV_{s,3,T} * IMR_{s,3,T} \tag{46}$$

The probability that age 2 sublegal sized fish in FRfish which is larger than the minimum size limit of FRfish and smaller than the minimum size limit for TOfish will remain below the size limit for TOfish at age 4 is:

$$PR_{s,2,F}\left\langle SL_{s,4,T}\middle|L_{s,2,F}\right\rangle = PR_{s,2,F}\left\langle SL_{s,3,T}\middle|L_{s,2,F}\right\rangle * (1-MR_{s,3}) * S_4 * PNV_{s,4,T} * IMR_{s,4,T} \tag{47}$$

The probability that age 2 sublegal sized fish in FRfish which is larger than the minimum size limit of FRfish and smaller than the minimum size limit for TOfish will remain below the minimum size limit for TOfish at age 5 is

$$PR_{s,2,F}\left\langle SL_{s,5,T}\middle|L_{s,2,F}\right\rangle = PR_{s,2,F}\left\langle L_{s,4,T}\middle|SL_{s,2,F}\right\rangle * (1-MR_{s,4}) * S_5 * PNV_{s,5,T} * IMR_{s,5,T} \tag{48}$$

The probability that age 2 sublegal sized fish in FRfish which is larger than the minimum size limit of FRfish and smaller than the minimum size limit for TOfish will remain below the minimum size limit for TOfish at any age is

$$PR_{s,2,F}\left\langle SL_{s,.,T} \middle| L_{s,2,F} \right\rangle = Z_2 * [(46)+(47)+(48)] \tag{49}$$

AGE 3: The probability that age 3 sublegal sized fish in FRfish which is larger than the minimum size limit of FRfish and smaller than the minimum size limit for TOfish will remain below the minimum size limit in TOfish at age 4 is:

$$PR_{s,3,F}\left\langle SL_{s,4,T} \middle| L_{s,3,F} \right\rangle = (1-MR_{s,3}) * S_4 * PNV_{s,4,T} * IMR_{s,4,T} \tag{50}$$

The probability that age 3 sublegal sized fish in FRfish which is larger than the minimum size limit of FRfish and smaller than the minimum size limit for TOfish will remain below the minimum size limit for TOfish at age 5 is:

$$PR_{s,3,F}\left\langle SL_{s,5,T} \middle| L_{s,2,F} \right\rangle = PR_{s,3,F}\left\langle SL_{s,4,T} \middle| L_{s,3,F} \right\rangle * (1-MR_{s,4}) * S_5 * PNV_{s,5,T} * IMR_{s,5,T} \tag{51}$$

The probability that an age 3 sublegal sized fish in FRfish which is larger than the minimum size limit of FRfish and smaller than the minimum size limit for TOfish will remain below the minimum size limit for TOfish at any age is

$$PR_{s,3,F}\left\langle SL_{s,.,T} \middle| L_{s,3,F} \right\rangle = Z_3 * [(50)+(51)] \tag{52}$$

AGE 4: The probability that an age 4 sublegal sized fish in FRfish which is larger than the minimum size limit of FRfish and smaller than the minimum size limit for TOfish will remain below the minimum size limit in TOfish at age 5 is:

$$PR_{s,4,F}\left\langle SL_{s,5,T} \middle| L_{s,4,F} \right\rangle = Z_4 * (1-MR_{s,4}) * S_5 * PNV_{s,5,T} * IMR_{s,5,T} \tag{53}$$

AGE 5: The probability that an age 5 sublegal sized fish in FRfish which is larger than the minimum size limit of FRfish and smaller than the minimum size limit for TOfish will remain below the minimum size limit in TOfish at age 5 is =0:

$$PR_{s,5,F}\left\langle SL_{s,5,T} \middle| L_{s,5,F} \right\rangle = 0 \tag{54}$$

Current CTC Model

In the current CTC Model, PVs are age-fishery specific, regardless of stock. This structure has two implications for implementation of total mortality regimes. First, interpretation of estimates of cumulative total mortalities or exploitation rates for a given stock across fisheries will be difficult. Because PVs of fish from a given stock and age can differ among fisheries even when those fisheries have identical size limits, different proportions of a cohort will be subject to landed catch and incidental mortalities. Second, the relationship between landed catch and incidental mortality is based on relative cohort sizes (age structure of the population). Stock-specific differences in size at

age are not considered when computing the composition of landed catches or incidental mortalities for a given fishery. When stock-age specific PVs are incorporated into the CTC model, estimates of the stock-age composition of landed catches and incidental mortalities will be expected to change. Stock-age composition is central to the computation of LCEs using either the AEQ or PR method because stock-specific maturation schedules are involved.

Application of PR Scalars

PR scalars are stock-age specific and depend upon the quantity being converted and the desired common currency. While PRs would ideally be applied to individual years because of variations in stock-age compositions and maturation rates, the 2008 Agreement calls for the use of averages. Consequently, application of PRs for implementation of total mortality regimes would involve the following steps:

Compile separate tables for each sector (troll, sport, net) included in AABM fisheries containing estimates for LC, LIM, SIM for the period 1985-1995. Compute average LIM:LC and SIM:LC for this period.

From CTC Model estimates of stock-age compositions for LC, LIM, and SIM components, compute PRs for each sector and year using equations (1)-(11), and 1985-1995 base period averages.

Compile a new Table 1, using appropriate sector allocation assumed for construction of Table 1 (e.g., 80:20 troll:sport).

For each AI, determine the LC, compute nominal values for LIM and SIM using the averages from step 1.
Convert nominal LC, LIM, SIM to sector LCEs using the averaged with landed catch, LIM, and SIM mortalities depicted for each sector

Compute PRs to convert LC, LIM, TIM sector mortalities for sport & net fisheries into troll LCE.

Compile a new Table 1, with landed catch, LIM, and SIM mortalities depicted for each sector in both nominal and LCE terms.

Develop a table of PR scalars for different types of conversions, e.g., SIMs to landed catch in a troll fishery. Implementation of total mortality regimes for AABM fisheries could involve several types of LCEs. It would not seem to be practical to try to portray all

Develop a table of PR scalars for different types of conversions, e.g., SIMs to landed catch in a troll fishery (See Directory to PR scalars to employ). Implementation of total mortality regimes for AABM fisheries could involve several types of LCEs. It would not seem to be practical to try to portray all potential combinations of conversions and different types of currency.

When converting different types of mortalities, simply multiply the quantity to be converted by the appropriate PR. Different allocations:

In terms of nominal fish, compute allocations and estimate associated encounters of fish subject to LIM, SIM.
Convert nominal encounters of LIM & SIM into mortalities by applying the appropriate incidental mortality rates.
Convert LC, LIM, SIM to troll LCEs.
Repeat (a) thru (c) until total troll LCEs = allowable level under the LCE version of Table 1.
Convert LC into allowable catches for use as catch ceilings for harvest management.

Note: A variation of the methods to compute PR scalars could be devised to generate scalars that reflect the probability of recruitment to a particular fishery, but is beyond the scope of this memo.

Notation:

a	Subscript for age
CDF	Cumulative Distribution Function
f	Subscript for fishery
F	Subscript indicating FRfish, the fishery from which mortalities are being converted
$IMR_{s,a,f}$	Incidental Mortality Rate for stock s, age a, in fishery f.
L	Legal mortality
LCE	Landed Catch Equivalent
LIM	Legal Incidental Mortality
$MR_{s,a}$	Probability that a fish of a given stock and age will mature. Note that maturation rates are estimated via cohort analysis methods and are hence stock and BY specific. The notation for maturation rates (MR) employed in this memo is generic, that is, it refers to BY-specific maturation rates for incomplete broods or average maturation rates for incomplete broods.
$PNV_{s,a,f}$	Proportion of a stock-age cohort that is NOT vulnerable to a fishery
$PR_{s,a,f}$	Probability that a fish of a given stock and age will recruit to a fishery
$PR_{s,a,f}\langle b\|a\rangle$	Probability of recruitment scalar to convert type *a* mortalities of a given stock, age, and fishery into an equivalent number of type *b* mortalities.
$PV_{s,a,f}$	Proportion of a stock-age cohort that is vulnerable to a fishery
s	Subscript for stock
S_a	Survival rate for age a fish before fishing
SIM	Sublegal Incidental Mortality
SL	Sublegal mortality
T	Subscript indicating TOfish, the fishery to which mortalities are being converted
X	Proportion of LC in FRfish which is sublegal in TOfish
Y	Proportion of sublegal fish in FRfish which would become legal in TOfish in absence of fishing
Z	Proportion of LC in FRfish which is below the size limit for TOfish

Directory for PR Scalar Formulas

Conversion Type			
TO	FROM	Relationship between size limits	Formulas
L	L	Size Limit FRfish = Size Limit TOfish	=1
		Size Limit FRfish > Size Limit TOfish	(12)
		Size Limit FRfish < Size Limit TOfish	(X), (13)-(23)
SL	SL	Size Limit FRfish = Size Limit TOfish	=1
		Size Limit FRfish > Size Limit TOfish	(25)
		Size Limit FRfish < Size Limit TOfish	(24)
L	SL	Size Limit FRfish = Size Limit TOfish	(1)-(11)
		Size Limit FRfish > Size Limit TOfish	(Y), (35)-(44)
		Size Limit FRfish < Size Limit TOfish	(26)-(34)
SL	L	Size Limit FRfish = Size Limit TOfish	Not possible = 0
		Size Limit FRfish > Size Limit TOfish	Not possible = 0
		Size Limit FRfish < Size Limit TOfish	(Z), (46)-(54)
L	L	Size Limit FRfish = Size Limit TOfish	=1
SL	SL		=1
L	SL		(1)-(11)
SL	L		Not possible = 0
L	L	Size Limit FRfish > Size Limit TOfish	(12)
SL	SL		(25)
L	SL		(Y), (35)-(44)
SL	L		Not possible = 0
L	L	Size Limit FRfish < Size Limit TOfish	(X), (13)-(23)
SL	SL		(24)
L	SL		(26)-(34)
SL	L		(Z), (46)-(54)

Appendix F. A simple schematic for an implementation tool for calculating landed catch equivalents and total mortality.

(1) Input CTC Model estimates for 1985-1995 (BP) stock composition for landed catch (LC), legal drop off (LIM), sublegal incidental mortalities (SIM), CNRlegal (LCNR), CNRsublegal (SLCNR) mortalities, PVs, AEQs, and MRs for each sector included in AABM fishery complexes.
(2) Compute average LCE values (e.g., AEQ, Prob Recruitment, etc.)
For each BP year, (a) compute mortality in terms of selected LCE. Example, AEQs:

$$LCE_{f,y} = \frac{\sum_s \sum_a Mort_{s,a,f,y} * AEQ_{s,a,f,y}}{\sum_s \sum_a Mort_{s,a,f,y}}$$

(b) compute BP average LCE within sector and average LCE in Troll LCEs

$$AvgLCE_f = \frac{\sum_{y=1985}^{1995} LCE_{f,y}}{11}$$

$$AvgLCE_{t/f} = \frac{AvgLCE_t}{AvgLCE_f}$$

(3) Use external encounter data? No, go to step 5.
(4) Input external encounter data. LC, L, SL, LCNRE, SLCNRE by year for BP). Compute encounters of IM per LC. Example, SIM:LC:

$$AvgS_f = \frac{\sum_{y=1985}^{1995} \frac{encS_{f,y}}{LC_{f,y}}}{11}$$

Go to step 6.
(5) Compute encounters of IM per LC from Model data. Example, SIM:LC:

$$AvgSIM_f = \frac{\sum_{y=1985}^{1995} \frac{encSIM_{f,y}}{LC_{f,y} * IM_{f,y}}}{11}$$

(6) Input incidental mortality rates to apply
(7) Compute average IM:LC by multiplying Avg encounters:LC by appropriate mortality rate.
(8) Use AABM sector allocations reflected in Appendix (e.g., troll:sport = 80:20)? No, go to step 11.
(9) Input sector allocation schedule by AI
(10) Compute nominal LC, LIM, SIM, LCNR, SLCNR & generate LCE table by sector for each AI level under specified schedule. Go to step 12
(11) Compute nominal LC, LIM, SIM, LCNR, SLCNR & generate LCE table by sector for each AI level using formulas presented in Appendix to 2008 Agmt.
(12) Compute troll LCE table.

Appendix G. Time series of postseason AI values generated by PSC Chinook Model calibration 0907.

Year	Alaska T	North T	WCVI T
1979	0.96	1.03	1.10
1980	1.02	0.97	0.96
1981	0.92	0.94	0.93
1982	1.09	1.06	1.01
1983	1.30	1.24	0.95
1984	1.48	1.41	1.01
1985	1.34	1.32	0.98
1986	1.51	1.48	1.03
1987	1.76	1.75	1.19
1988	2.17	1.87	1.12
1989	1.87	1.69	0.98
1990	1.90	1.65	0.89
1991	1.80	1.53	0.75
1992	1.67	1.41	0.78
1993	1.68	1.43	0.69
1994	1.58	1.26	0.52
1995	1.06	0.98	0.41
1996	0.94	0.93	0.49
1997	1.25	1.12	0.58
1998	1.20	1.01	0.56
1999	1.09	0.95	0.49
2000	0.97	0.94	0.50
2001	1.17	1.21	0.77
2002	1.76	1.70	1.13
2003	2.21	1.91	1.19
2004	2.06	1.81	0.98
2005	1.81	1.55	0.79
2006	1.51	1.24	0.62
2007	1.20	0.98	0.53
2008	1.01	0.93	0.64